PB88-245907

Evaluation of the B.E.S.T. (Trade Name) Solvent Extraction Sludge Treatment Technology Twenty-Four Hour Test

Enviresponse, Inc., Livingston, NJ

Prepared for

Environmental Protection Agency, Cincinnati, OH

Aug 88

U.S. Department of Commerce
National Technical Information Service
NTIS

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO.
EPA/600/2-88/051

2.

3. RECIPIENT'S ACCESSION NO.
PB88-245907

4. TITLE AND SUBTITLE
Evaluation of the B.E.S.T.^{tm} Solvent Extraction Sludge Treatment Technology Twenty-four Hour Test

5. REPORT DATE
August 1988

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)
Gerard W. Sudell

8. PERFORMING ORGANIZATION REPORT NO.

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Enviresponse, Inc.
Edison, New Jersey 08837

10. PROGRAM ELEMENT NO.

11. CONTRACT/GRANT NO.
68-03-3255

12. SPONSORING AGENCY NAME AND ADDRESS
Risk Reduction Engineering Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

13. TYPE OF REPORT AND PERIOD COVERED

14. SPONSORING AGENCY CODE
EPA/600/14

15. SUPPLEMENTARY NOTES

Project Officer: Mary Stinson (201) 321-6683

16. ABSTRACT

A twenty-four hour sampling and analytical effort was conducted on Resources Conservation Co.'s Solvent Extraction Sludge Treatment Technology prototype full-scale commercial facility while operating at the General Refining Superfund site in Garden City, Georgia. The site was contaminated with oily residues resulting from waste oil re-refining and reclamation operations. The B.E.S.T.^{tm} sludge treatment technology was tested to determine its suitability as a transportable on-site treatment technology for spill and waste site cleanups, with special potential for oily hazardous waste materials. The process separates oily sludges into their component oil, solids, and water fractions, and conditions them for disposal or for further treatment. The test data confirm the system's capability to separatethe sludges, often in efficiencies of over 98%. Comparison of laboratory simulation data to field data indicate that laboratory-scale simulations can be useful in predicting system performance. Further testing is needed to confirm the system efficiencies and develop complete operating cost data.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT
Release to public

19. SECURITY CLASS *(This Report)*
Unclassified

20. SECURITY CLASS *(This page)*
Unclassified

21. NO. OF PAGES
186

22. PRICE
A09 19.95

EPA Form 2220-1

PB88-245907

EPA/600/2-88/051
August 1988

EVALUATION OF THE B.E.S.T.^{tm} SOLVENT EXTRACTION SLUDGE TREATMENT TECHNOLOGY TWENTY-FOUR HOUR TEST

by
Gerard W. Sudell
Enviresponse, Inc.
Edison, New Jersey 08837

EPA Contract 68-03-3255

Project Officer
Mary K. Stinson
Releases Control Branch
Edison, New Jersey 08837

Prepared for
U.S. Environmental Protection Agency Region X
Seattle, Washington 98101

RISK REDUCTION ENGINEERING LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

NOTICE

This document has been reviewed in accordance with U.S. Environmental Protection Agency policy and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

FOREWORD

Today's rapidly developing and changing technologies and industrial products and practices frequently carry with them the increased generation of materials that, if improperly dealt with, can threaten both public health and the environment. The U.S. Environmental Protection Agency is charged by Congress with protecting the Nation's land, air, and water systems. Under a mandate of national environmental laws, the agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. These laws direct the EPA to perform research to define our environmental problems, measure the impacts, and search for solutions.

The Risk Reduction Engineering Laboratory is responsible for planning, implementation, and management of research, development, and demonstration programs to provide an authoritative, defensible engineering basis in support of the policies, programs, and regulations of the EPA with respect to drinking water, wastewater, pesticides, toxic substances, solid and hazardous wastes, and Superfund-related activities. This publication is one of the products of that research and provides a vital communication link between the researcher and the user community.

This report was prepared at the request of USEPA's Region X. It presents information collected from a twenty-four hour test of the B.E.S.T.^{tm} solvent extraction sludge treatment technology during its removal action operation at the General Refining Co. site in Garden City, Georgia. The report supplies a brief description of the site and the B.E.S.T.^{tm} process, and presents the sampling and analytical results obtained during the test. The data are evaluated and some conclusions are offered. For further information, please contact the Superfund Technology Demonstration Division of the Risk Reduction Engineering Laboratory.

E. Timothy Oppelt, Acting Director
Risk Reduction Engineering Laboratory

ABSTRACT

A twenty-four hour sampling and analytical effort was conducted on Resources Conservation Co.'s Solvent Extraction Sludge Treatment Technology prototype full-scale commercial facility while operating at the General Refining Superfund site in Garden City, Georgia. The site was contaminated with oily residues resulting from waste oil re-refining and reclamation operations. The B.E.S.T.^{tm} sludge treatment technology was tested to determine its suitability for application as a transportable on-site treatment technology for spill and waste site cleanups, with special potential for oily hazardous waste materials. The process separates oily sludges into their component oil, solids, and water fractions, and conditions them for disposal or for further treatment.

The test data confirm the system's capability to separate the sludges, often in efficiencies of over 98%. Comparison of laboratory simulation data to field data indicate that laboratory-scale simulations can be useful in predicting system performance. Further testing is needed to confirm the system efficiencies and develop complete operating and cost data.

CONTENTS

Foreword iii
Abstract iv
Figures vi
Tables vii
Abbreviations and Symbols ix
English/Metric Conversion Factors x
Acknowledgement xi

1 Introduction 1
2 Summary and Conclusions 5
3 General Refining Site Description 7
4 Process Description 15
5 General Refining Test Results 26
  Operations 26
  Separation performance 28
  Contaminant separation 31
  Comparisons of field and laboratory data 44
6 Quality Assurance/Quality Control 50

Bibliography 58

Appendices

A. Sampling and analysis plan for performance evaluation testing A-0

B. Data Summary, February 26 and 27, 1987, B.E.S.T.^{tm} Sludge Treatment Process at the General Refining Co. Site, Garden City, Georgia B-0

C. Material safety data sheet - Triethylamine . . C-0

FIGURES

Number		Page
1	General Refining site location	8
2	General Refining site lagoons 1, 2, and 3 . . .	9
3	General Refining Site	11
4	Sludge sampling	14
5	B.E.S.T.^{tm} sludge processing unit on location.	16
6	Triethylamine-water solubility curve	17
7	Separation diagram	19
8	Operations site plan	20
9	Process flow diagram	22
10	Water treatment plant	24
11	Process overview	25
12	Sample locations identification	27

TABLES

Number		Page
1	Test Program Development Chronology	3
2	General Refining B.E.S.T.^{tm} Cleanup Performance Test Results Table of Contents	4
3	Site Contaminants	10
4	Sample Listing	12
5	Sludge Feed Composition During The Twenty-four Hour Test	13
6	Test Parameters Listing	29
7	Overall Material Balance	30
8	BEST^{tm} Unit Separation Performance	30
9	Operating Data	32
10	Metals Analytical Results	33
11	Total Metals Material Balance	33
12	Volatile Organics Analytical Results	35
13	Semivolatile Organics Analytical Results . . .	36
14	Lead and PCB Analytical Results	38
15	PCB Material Balance	38
16	Lead Material Balance	39
17	Oil and Grease and Triethylamine Analytical Results	39
18	TEA Material Balance	41
19	Chlorinated Dioxins and Furans in the Feed Sludge	42

TABLES (continued)

Number		Page
20	TCLP Analytical Results	43
21	Air Emissions Results	45
22	Recycle Triethylamine Hazardous Substance List Volatiles Analytical Results	46
23	Comparison of General Refining Laboratory Data to Full-Scale Processing Data	47
24	Laboratory Phase Separation Data for General Refining Sludge vs. Other Materials	47
25	Laboratory Contaminant Partitioning Data for General Refining Sludge vs. Other Materials	49
26	Sample Quantities and Field Duplicates	52
27	Laboratory Control Sample Report: Gas Chromatography/Mass Spectrometry	54
28	Laboratory Control Sample Report: Gas Chromatography	54
29	Surrogate Control Sample Report: Gas Chromatography/Mass Spectrometry	55

LIST OF ABBREVIATIONS AND SYMBOLS

Al	Aluminum
API	American Petroleum Institute
^{o}API	A unit of viscosity
As	Arsenic
Ba	Barium
BDAT	Best Demonstrated Available Technology
B.E.S.T.^{tm}	RCC's trademark for the Solvent Extraction Sludge Treatment System
BNA	Base Neutral/Acid (Extractables)
BOD	Biological Oxygen Demand
BS&W	Bottom Sediment and Water
BTX	Benzene, Toluene, Xylene
CLP	Contract Laboratory Program
COD	Chemical Oxygen Demand
Cr	Chromium
Cu	Copper
EP	Extraction Procedure
EPA	Environmental Protection Agency
ERCS	Emergency Response Cleanup Services
Fe	Iron
Hg	Mercury
HSL	Hazardous Substance List
HWERL	Hazardous Waste Engineering Research Laboratory
HX	Heat Exchanger
lb/hr	Pounds per hour
mg/l	Milligrams per liter
mg/kg	Milligrams per kilogram
ml	Milliliter
Mn	Manganese
N	Nitrogen
Ni	Nickel
O&G	Oil and Grease
Pb	Lead
PCB	Polychlorinated Biphenyls
POTW	Publicly Owned Treatment Works
ppb	Parts per billion
ppm	Parts per million
ppmvd	Parts per million, dry volume basis
QA/QC	Quality Assurance/Quality Control
RCB	Releases Control Branch
RCC	Resources Conservation Co.
RCRA	Resource Conservation and Recovery Act
S&A	Sampling and Analytical
Se	Selenium
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total Dissolved Solids
TEA	Triethylamine
TKN	Total Kjeldhal Nitrogen
Zn	Zinc

ENGLISH/METRIC CONVERSION FACTORS

	Equals
1 cubic foot	0.0283 cubic meters
1 foot	0.3048 meters
1 US gal.	3.785 liters
1 inch	2.54 centimeters
1 ounce	28.35 grams
1 part per billion (ppb)	One part in 10^9. For gaseous mixtures, a volume:volume basis is typically used and 1 ppb is on the order of 1 ug/m^3: $ug/m^3 = ppb \times \frac{RT}{MW}$ where RT = 22.4 L/mole at 0^o and 1 atm = 24.5 L/mole at 25^o and 1 atm For liquid materials, a weight:volume basis is most commonly used and 1 ppb = 1 ug/L (= 1 ug/kg for liquids with density = 1). For solid materials, a weight:weight basis is most commonly used and 1 ppb = 1 ug/kg.
1 part per million (ppm)	One part in 10^6 1 ppm = 1 mg/m^3 gaseous streams 1 ppm = 1 mg/l liquid streams 1 ppm = 1 mg/kg solid streams
1 pound	453.6 grams
1 U.S. quart	0.9463 liters
1 short ton	907.2 kilograms

ACKNOWLEDGEMENT

We wish to acknowledge the extensive assistance and comments from John J. Barich III of EPA's Region X Environmental Services Division, and key personnel at Resources Conservation Co., particularly Mark K. Tose and R. Reams Goodloe, Jr., for their contributions to this document. Comments and suggestions received from Edward R. Bates, Alternative Technologies Division, Hazardous Waste Engineering Research Laboratory, were also instrumental in developing the final report copy. EPA's Region IV Emergency Response and Control Branch provided information concerning site operations.

SECTION 1

INTRODUCTION

This report presents an evaluation of the B.E.S.T.^{tm} solvent extraction sludge treatment technology data that were generated during a twenty-four hour performance test conducted at the General Refining site in Garden City, Georgia. The test was conducted by the Resources Conservation Co. (RCC) with the assistance of EPA's Region X Environmental Services Division in cooperation with EPA's Region IV Emergency Response and Control Branch.

The General Refining site, located near Savannah, Georgia, was operated as a waste oil reclamation and re-refining facility from the early 1950s until 1975. Sulfuric acid used to treat the waste oil produced an acidic oily sludge, while process filtration produced an oily filter cake byproduct. The sludge was disposed of in four unlined lagoons, and the filter cake was buried and stockpiled on site.

To remedy the situation, site cleanup actions were initiated in the summer of 1986 to stabilize the site, secure the facility, and explore disposal alternatives. In evaluating disposal alternatives, consideration was given to on-site and off-site incineration, landfilling, and on-site solvent extraction. Except for landfilling, all options offered an ultimate solution to waste disposal. The B.E.S.T.^{tm} solvent extraction process was chosen as the most suitable and cost-effective option.

In mid 1986 RCC mobilized and installed its prototype full-scale commercial solvent extraction sludge treatment system at the General Refining site in response to EPA's Region IV request for a removal action at the site under contract to Haztech, Inc., the EPA's ERCS contractor for the operation. After shakedown and modification of the prototype 100 ton/day system, approximately 3,700 tons of oily sludges from the petroleum re-refining operations were treated. The B.E.S.T.^{tm} system operation concluded in March 1987.

The initial sampling and analytical activity conducted during the removal operation was directed at verifying the composition of the product streams. RCC's previous analysis efforts were directed toward evaluating API sludges at the laboratory-scale level. These efforts resulted in data that tracked the isolation of contaminants into the oil, water, and solids fractions, and also determined EP toxicity and TCLP results for the solids residues. The General Refining operation provided the opportunity to compare a prototype full-scale commercial facility's data with the laboratory-scale data for the treatment of hazardous waste sludges.

In early February 1987, RCC decided to obtain test data during the system's final week of operation at the site since the system had been operating for some time, was essentially debugged, and had an experienced operating crew to control the process. RCC contacted EPA's Region X for support and advice, after which RCC and Region X developed and implemented a twenty-four hour sampling and analysis effort to evaluate the system's performance and efficiency both in the separation of the feed components and in the isolation of contaminants into specific product streams. The test program was completed within a week after agreement was reached to perform the test. During this week, the sampling and analysis plan was developed, and the testing and analytical contractors selected. The time for development of the plan and implementation of the sampling program was brief, as shown in Table 1. The test program was tailored to meet the constraints imposed by the primary purpose of the operation - the removal action initiated by EPA's Region IV. By selecting an EPA contract laboratory for sample analysis, the test program was able to be organized and completed quickly without major quality assurance complications.

This report is divided into six sections: Introduction; summary and conclusions outlining the performance of the technology during the sampling effort; a brief description of the General Refining site; description of the technology; discussion of the system operation and data collected during the test period; and quality assurance/quality control.

Detailed results of the test have been assembled into six three-ring notebooks, which include copies of the analytical data and the laboratory quality assurance/quality control data. Table 2 presents the contents of the analytical notebooks. In addition, RCC maintains logbook records, computer control system archive files of operations during the test period, and chain-of-custody data records for the samples.

TABLE 1. TEST PROGRAM DEVELOPMENT CHRONOLOGY

Date	Event
2/21/87	RCC discusses desirability of obtaining test data at the General Refining site.
2/23/87	RCC contacts Region X for comments and advice.
2/24/87	Sampling and analysis plan developed.
2/25/87	Region X provides QA/QC-certified sample bottles to the General Refining site.
2/23 to 2/25/87	RCC obtains quotations on analytical and environmental sampling services.
2/26/87	Sample bottles arrive on site and test begins.
2/27/87	Test ends.

TABLE 2. GENERAL REFINING B.E.S.T.^{tm} CLEANUP PERFORMANCE TEST RESULTS TABLE OF CONTENTS

Volume 1.	ENSECO Analytical Results for Resources Conservation Company Enseco Project 63109 Dated April 30, 1987	
Volume 2.	ENSECO Data Package Case 6955, QC #7227	
Volume 3.	ENSECO Data Package Case 6955, QC #7227 continued	
Volume 4.	ENSECO Data Package Case 6995, QC #7228	
Volume 5.	ENSECO Data Package Case 6995, QC #7228 continued	
Volume 6.	1a)	Rocky Mountain Analytical, Inorganic Analysis Dated 4/6/87
	2a)	Rocky Mountain Analytical, Inorganic Analysis Dated 3/24/87
	3a)	Rocky Mountain Analytical, Inorganic Analysis Dated 3/23/87
	1b)	Entropy Environmentalists Inc., Stationary Source Sampling Report, Dated 2/26-28/87
	2b)	ENSECO Analytical Results Dated 4/8/87

SECTION 2

SUMMARY AND CONCLUSIONS

The B.E.S.T.^{tm} solvent extraction sludge treatment 100 ton/day prototype commercial facility operation at the General Refining site demonstrated the system's capability to separate oily feedstock into its oil, water, and solids product fractions and to concentrate certain contaminants into a specific product fraction. An evaluation of the separation performance shows that metals were separated and isolated mostly into the solids fraction; PCBs were concentrated into the oil fraction; and the water product, after additional on-site treatment, was suitable for disposal in a nearby industrial wastewater treatment system. Separation efficiencies, defined as the amount of desired product less the amount of all undesired products times 100, often exceeded 98%. The solids product stream was shown to contain less than 0.5% moisture, with very little oil contamination; the oil product contained only 0.88% water; and the water product contained 0.0033% oil and less than .81% total solids.

After separation, the streams were analyzed for contaminant concentrations to ascertain that specific key contaminants had concentrated preferentially into a prescribed product fraction. The contaminants of interest were PCBs, lead, metals, volatiles, semivolatiles, and chlorinated dioxins and furans. In general, the PCBs, volatiles, and semivolatiles concentrated in the oil fraction, with little contamination found in the solids and water product fractions. Metals mostly concentrated in the solids fraction but lead (Pb) concentrated into both the solid and oil fractions, suggesting that lead initially was bound inorganically as well as organically. Chlorinated dioxins and furans were below detection limits in the raw sludge feed. On-site water treatment reduced most levels of contaminants in the discharged treated product water, maintaining about the same semivolatiles concentrations, slightly reduced volatiles, and significantly reduced metals concentrations.

The overall system operation during the test period resulted in the generation of important correlations between feedstock constituents and system performance, and provided the opportunity to determine the validity of comparing laboratory-scale data to full-scale operational data. The data show good correlation of both separation efficiencies and contaminant partitioning to specific product streams.

Future evaluations of the system should be designed to generate additional information that will confirm further the efficacy of the system, and could include:

- Accumulation of additional data on a variety of feedstocks to establish the range of the applicability of the process.
- Measurements required to further verify existing data or compare laboratory-scale data with field data.
- Verification of system performance over an extended period of time.
- Collection of samples at key process points within the system to accumulate a larger data base to assist in system performance evaluations.
- Identification of process variables and analytical information needed to develop mass and energy balances.
- Identification of the investment and operating cost information needed to develop a projected treatment cost for the technology, in units of dollars per ton of treated material.
- Verification that startup and system operational difficulties have been overcome.
- Monitoring of ambient air at strategic peripheral locations to track system fugitive emissions.

The General Refining operation was the first full-scale test of the B.E.S.T.^{tm} sludge treatment technology. Further testing over an extended period of time should be undertaken when the system is operating at another site. The current data confirms the system's capability to perform as designed. Data collected over a longer period of time can aid in the affirmation of the effectiveness of the process.

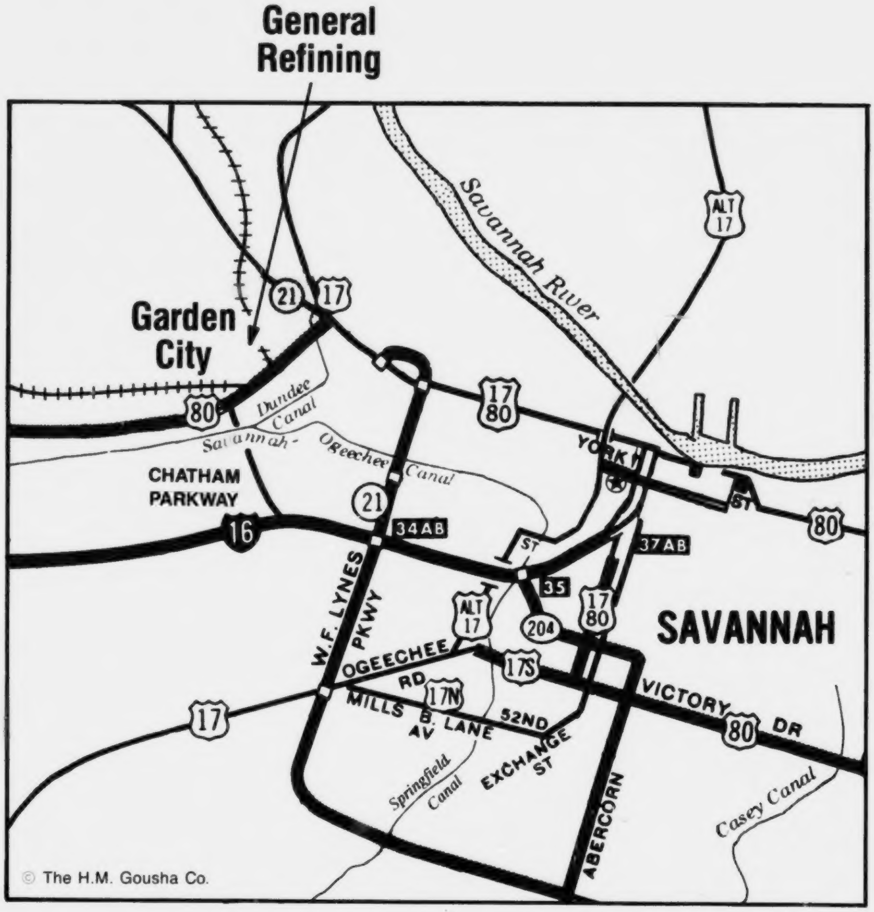
SECTION 3

GENERAL REFINING SITE DESCRIPTION

The General Refining site was used from the early 1950s to 1975 as a waste oil reclamation and re-refining facility. The site is located off Route 80, Chatham County, in Garden City, Georgia, west of Savannah (Figure 1). The by-product acidic oily sludges from the process were disposed of in four unlined lagoons, and the oily filter cake was buried or stockpiled on site. An additional unlined lagoon that had been used as an oil/water separator was backfilled with filter cake and sludge, and waste oil was stored in bulk tanks on site. The total volume of waste was estimated to be in excess of 10,000 tons. Analysis of the waste oil, sludge, and filter cake performed during an early material characterization phase of the project revealed the presence of petroleum compounds, heavy metals including lead and copper, PCBs, and low pH sludges and water. An analysis of the waste material is shown in Table 3.

Since the site is located in the Coastal plains and is characterized by sandy, permeable soils with a shallow groundwater table, concern was expressed that the abandoned site could contribute to groundwater contamination; or that contaminants could migrate into an adjoining drainage ditch, then into the Dundee Canal, and subsequently into the Savannah River. After being contracted by Haztech, RCC implemented a three-phase approach to identify the site waste characteristics, establish standards for the system operation, and determine waste disposal techniques. Preliminary work included a detailed analysis of all the waste streams and pond strata to identify treatment and disposal requirements. Pilot-scale testing was conducted to evaluate each waste component to determine treatment system operating requirements. After the initial studies the solvent extraction sludge treatment system was mobilized, and on-site operation commenced.

During the initial site work it was determined by visual observation that the sludge depth in all four lagoons was about three to five feet, thereby minimizing the necessity for depth profile sampling. The total depth of lagoon 1 was about two feet, and was mainly sludge. The sludge in lagoons 2, 3, and 4 was floating on a free water layer. Lagoon 3 was the largest of the four, and lagoon 1 the smallest (Figure 2). To obtain the


General Refining
Garden City
21
17
80
Dundee Canal
Savannah - Ogeechee Canal
Savannah River
ALT 17
17 80
CHATHAM PARKWAY
21
16
34AB
YORK
ST
80
ST
37AB
35
17 80
ALT 17
204
SAVANNAH
W.F. LYNES PKWY
OGEECHEE RD
17S
17N
MILLS B. LANE
AV
52ND
EXCHANGE ST
VICTORY DR
80
17
Springfield Canal
ABERCORN
Casey Canal
© The H.M. Gousha Co.

SOURCE: RESOURCES CONSERVATION CO., BELLEVUE, WA.

Figure 1. General Refining site location.

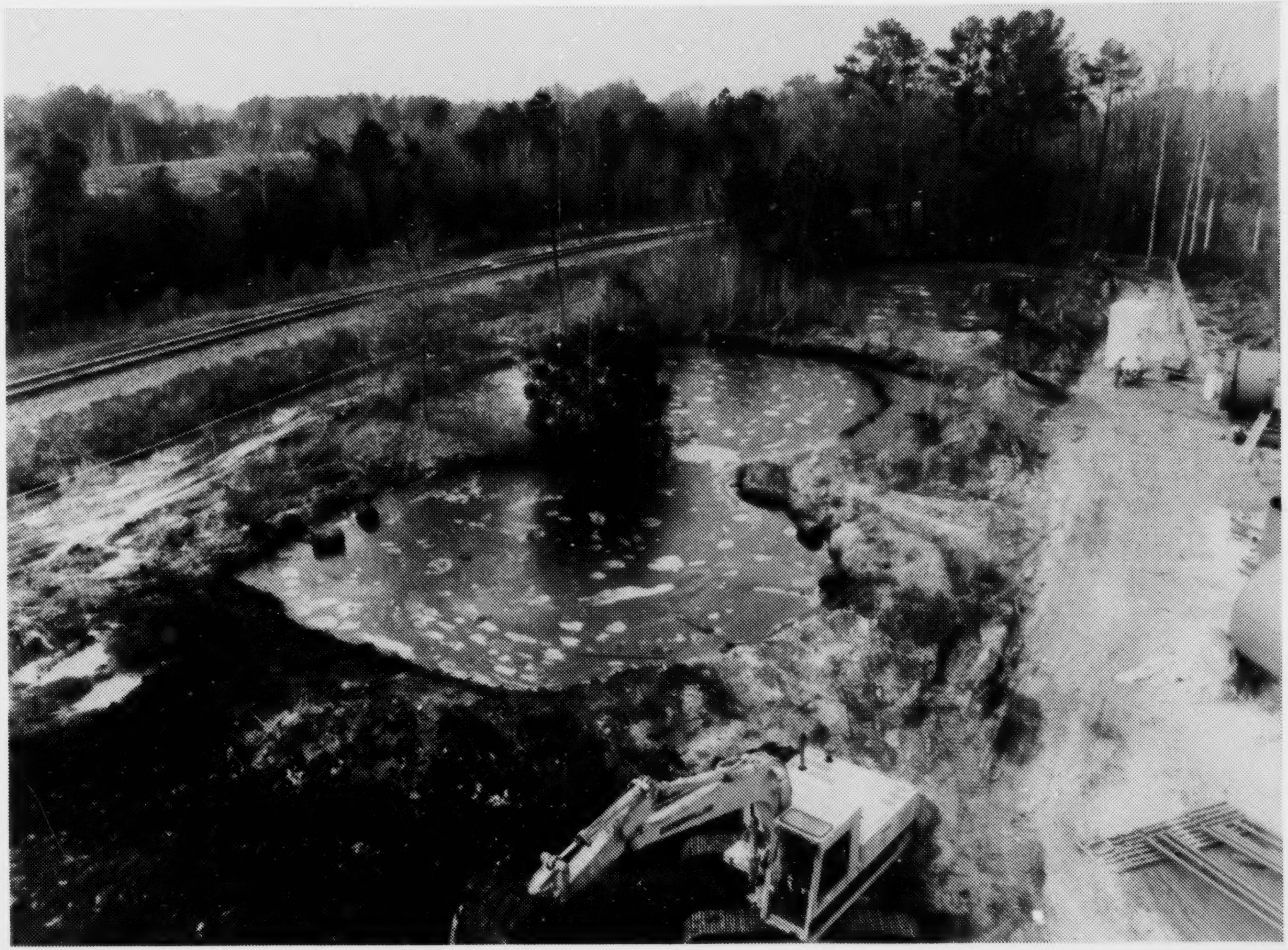


Figure 2. General Refining site lagoons 1, 2, and 3.

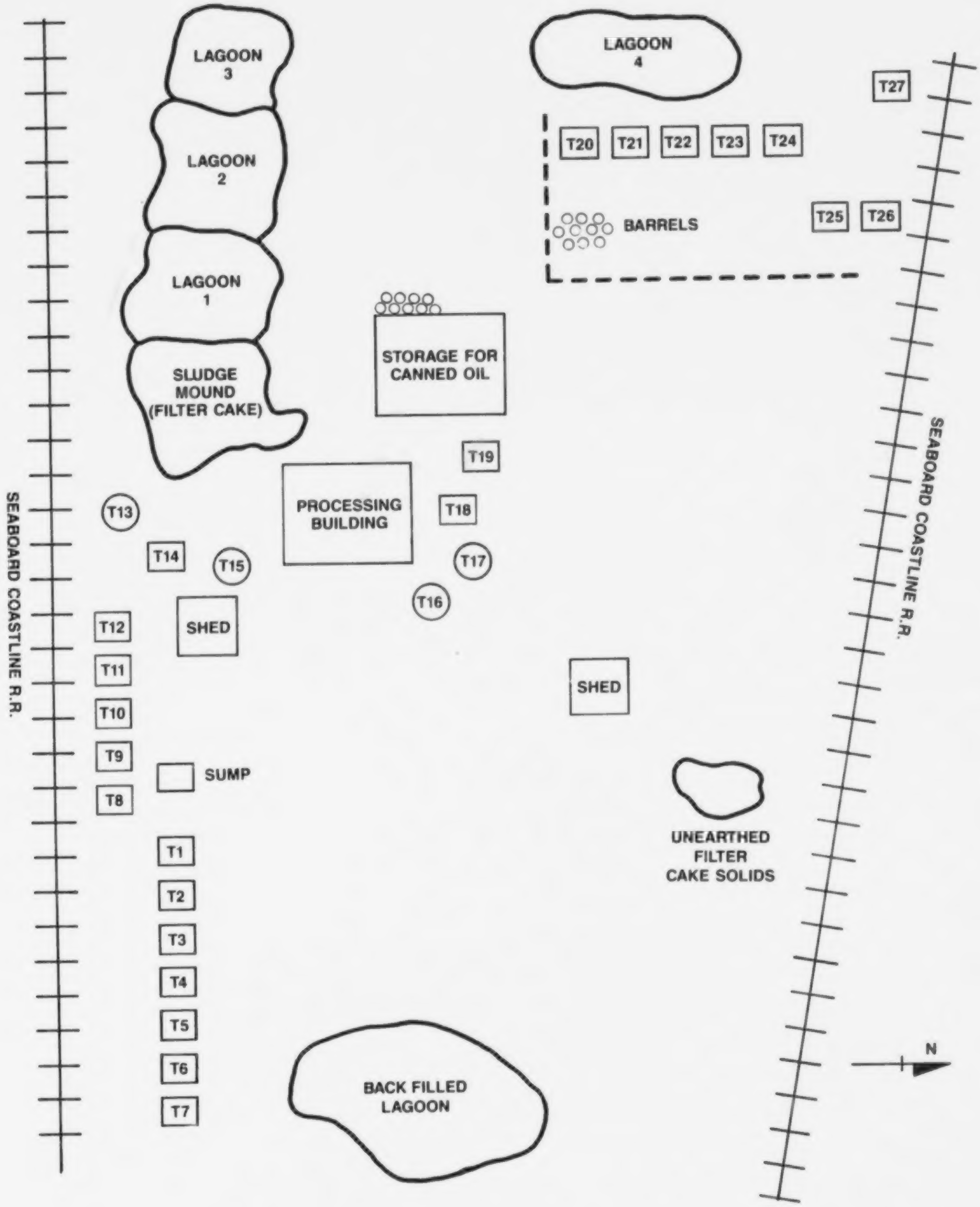
TABLE 3. SITE CONTAMINANTS

Location	pH	Lead (ppm)	Copper (ppm)	PCB (ppm)	Oil & Grease(%)
Lagoon Sludge	1.3-1.6	200-5900	83-87	4.4-5.0	15-20%
Filter Cake	3.3	10000	190	3.5	30-40%
Buried Lagoon	0.63	8100	170	2.9	30-40%
Waste Oil	3.3-7.0	170-1700	16-190	< 1	N/A

samples for the material characterization, drums were composited from materials in the four lagoons. Samples of the site well water, three oil tanks, and several soil core samples adjacent to the lagoons also were taken. Filter cake materials were sampled at approximately ten surface locations in the solids pile adjacent to lagoon 1, at the filter cake pile outside the fence, and at the backfilled lagoon (Figure 3). A listing of the sample locations and sample types is given in Table 4.

Examination of the composited lagoon sludge samples determined that the sample was not homogeneous and had stratified into two distinct layers. Since the two layers could not be homogenized, the sample was separated into two samples for analysis. It was determined that the only additional samples (of those that were initially collected) that were required for feed composition analysis to adequately characterize the site, were backfilled lagoon and lagoon sediments. The following are the feed stocks finally analyzed for composition (percent oil, water, and sludge) and subjected to laboratory glassware simulation testing:

- Lagoon 1
- Lagoons 2-4 surface
- Lagoons 2-4 subsurface
- Lagoons 2-4 surface & free water in proportionate quantities
- Filter cake


LAGOON 3
LAGOON 2
LAGOON 1
SLUDGE MOUND (FILTER CAKE)
LAGOON 4
T27
T20
T21
T22
T23
T24
BARRELS
T25
T26
STORAGE FOR CANNED OIL
T19
PROCESSING BUILDING
T18
T17
T16
SEABOARD COASTLINE R.R.
SEABOARD COASTLINE R.R.
T13
T14
T15
T12
SHED
T11
T10
T9
T8
SUMP
SHED
UNEARTHED FILTER CAKE SOLIDS
T1
T2
T3
T4
T5
T6
T7
BACK FILLED LAGOON
N

SOURCE RESOURCES CONSERVATION CO., BELLEVUE, WA

Figure 3. General Refining site.

TABLE 4. SAMPLE LISTING

Location	Sample type
Lagoon 1	sludge
	sediment
	core
Lagoon 2	lagoon surface
	lagoon subsurface
	sludge
	sediment
	core
	water
Lagoon 3	lagoon surface
	lagoon subsurface
	sludge
	sediment
	core
	water
Lagoon 4	lagoon surface
	lagoon subsurface
	sludge
	sediment
	water
Oil Tanks	
T3	liquid
T5	liquid
T6	liquid
Soil	soil
Site well water	liquid
Sludge mound	filter cake
Backfilled lagoon	sediment

- Backfilled lagoon
- Lagoons 1-4 sediment

The original scope of work agreed to by Haztech Inc. and RCC did not include analysis of PCBs. However, after it was determined that the PCB levels in the oil product could have an effect on disposition of the oil, an investigation of the PCB levels in the oil product stream from the laboratory treatment of the various on-site materials was conducted. The PCB concentration in three oil storage tanks on site and in the system water product also were determined.

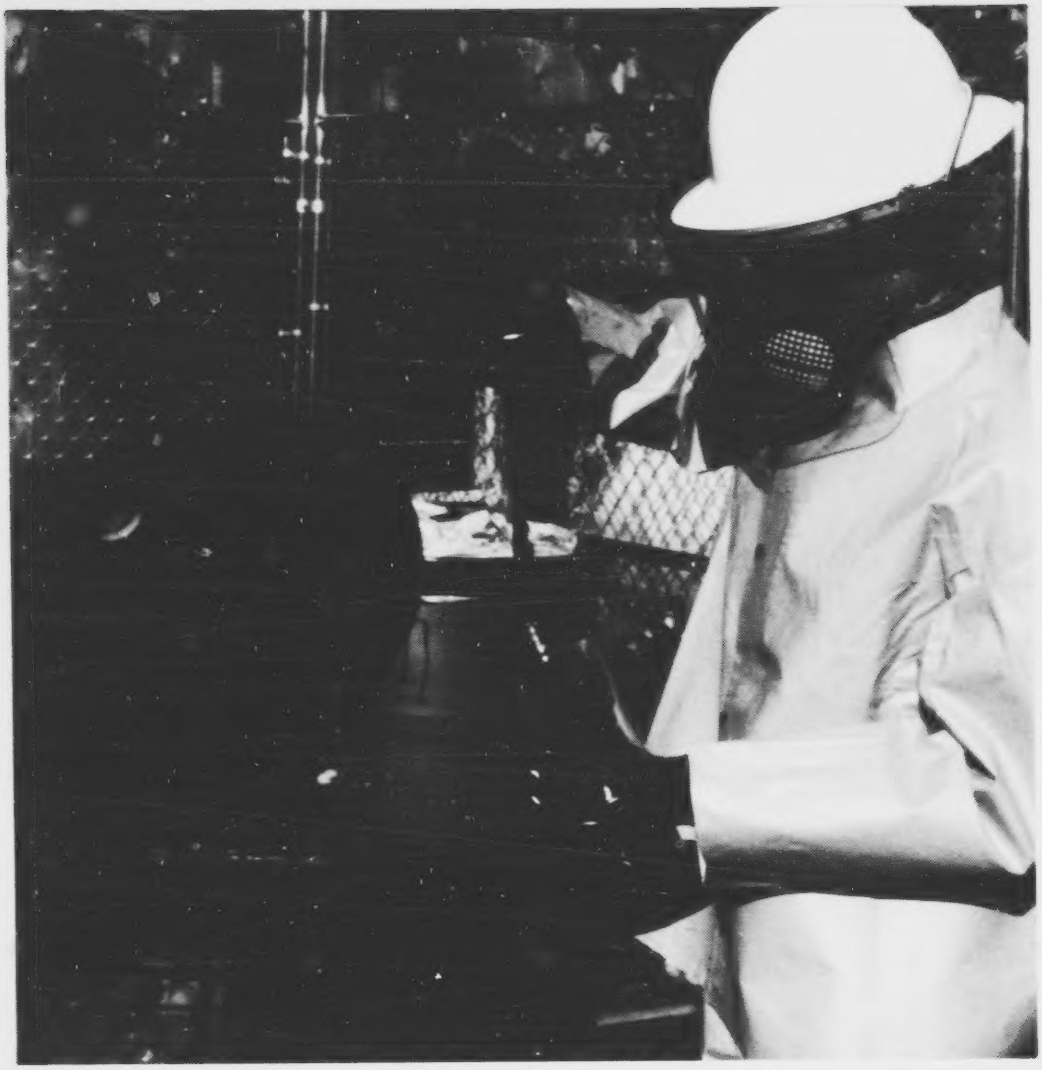
Composition of the sludges and soils at the site varied widely from point to point laterally and vertically within the lagoons. Nominal composition in weight percent was approximately 10% oil, 70% water, and 20% solids, but during actual operation oil ranged from 0-40%, water from 60-100%, and solids from 2-30%. PCBs ranged from 1 to 13 mg/kg and lead ranged from 2200 to 7400 ppm. During the twenty-four hour test period the feed was fairly consistent, as shown in Table 5.

The sludge at the site exhibited some unusual physical properties. The untreated sludge formed an emulsion that was hydrophobic and could not be mixed with water (Figure 4). The sludge was determined to be rheopectic, since mixing acted to increase its viscosity, changing it from a paste-like state to a semi-solid. Viscosity readings on several samples ranged from 490,000 to 530,000 centipoise Brookfield.

The cleanup involved neutralizing the sludge from the lagoons and then processing it through the B.E.S.T.^{tm} solvent extraction system where it was separated into its oil, water, and solids product fractions. Some of the oil was transported off site with the remainder stored on site for subsequent treatment; the water was first treated on site and then transported to a nearby industrial wastewater treatment system; and the solids were stored on site.

TABLE 5. SLUDGE FEED COMPOSITION DURING THE TWENTY-FOUR HOUR TEST

Sample	wt. % Oil	wt. % Water	wt. % Solids
2/26 1345 hrs.	28	65	7
2/26 1637 hrs.	26	66	8
2/26 2017 hrs.	27	66	7
2/27 0017 hrs.	28	65	7
2/27 1245 hrs.	27	66	7



SOURCE: RESOURCES CONSERVATION CO., BELLEVUE, WA.

Figure 4. Sludge sampling.

SECTION 4

PROCESS DESCRIPTION

The Resources Conservation Co.'s prototype full-scale commercial facility has a nominal capacity of 100 tons/day wet throughput. The system is modular, is capable of being transported to contaminated sites for operation and cleanup, and offers the capability to include all required on-site utilities except for electricity and potable water (Figure 5).

The B.E.S.T.^{tm} sludge treatment system processes difficult-to-treat emulsified oily sludges by breaking the emulsion and physically separating the sludge into three separate fractions. These fractions--oil, water and solids--then can be handled separately. As the fraction separations take place, certain contaminants can be removed from the original sludge and concentrated into a specific phase, such as PCBs concentrating in the product oil fraction, and metals concentrating in the product solids fraction. This separation can serve to assist in determining the suitability of the separated fractions for recycling or reuse, or in determining the most appropriate method for disposal.

The process uses one or more of a family of aliphatic amine solvents to break oil/water emulsions and release bonded water from the sludge. The solvent used at the General Refining site, triethylamine (TEA), becomes completely miscible with water when cooled below 20°C, but upon heating becomes immiscible (Figure 6). (Additional characteristics of TEA solvent are included in Appendix C.) To take advantage of this property, the process mixes refrigerated TEA solvent with the oily sludges. The solvent liquifies the sludge and turns the mixture into a homogeneous solution. Since the temperature is kept below the solubility curve, solids are no longer bonded by the oil/water emulsion that was part of the original sludge, and they are released from the emulsion. Once the solids are removed, the temperature of the liquid fraction is heated above the solubility point, and the water separates from the oil and solvent. The last step in the process is to remove the solvent from the oil and water fractions using distillation techniques.

The oil fraction is chemically unaltered by the process and contains the same constituents as the original material. The objective is to recover and reuse this fraction as a fuel or process feedstock. The feasibility of reuse is dependent upon

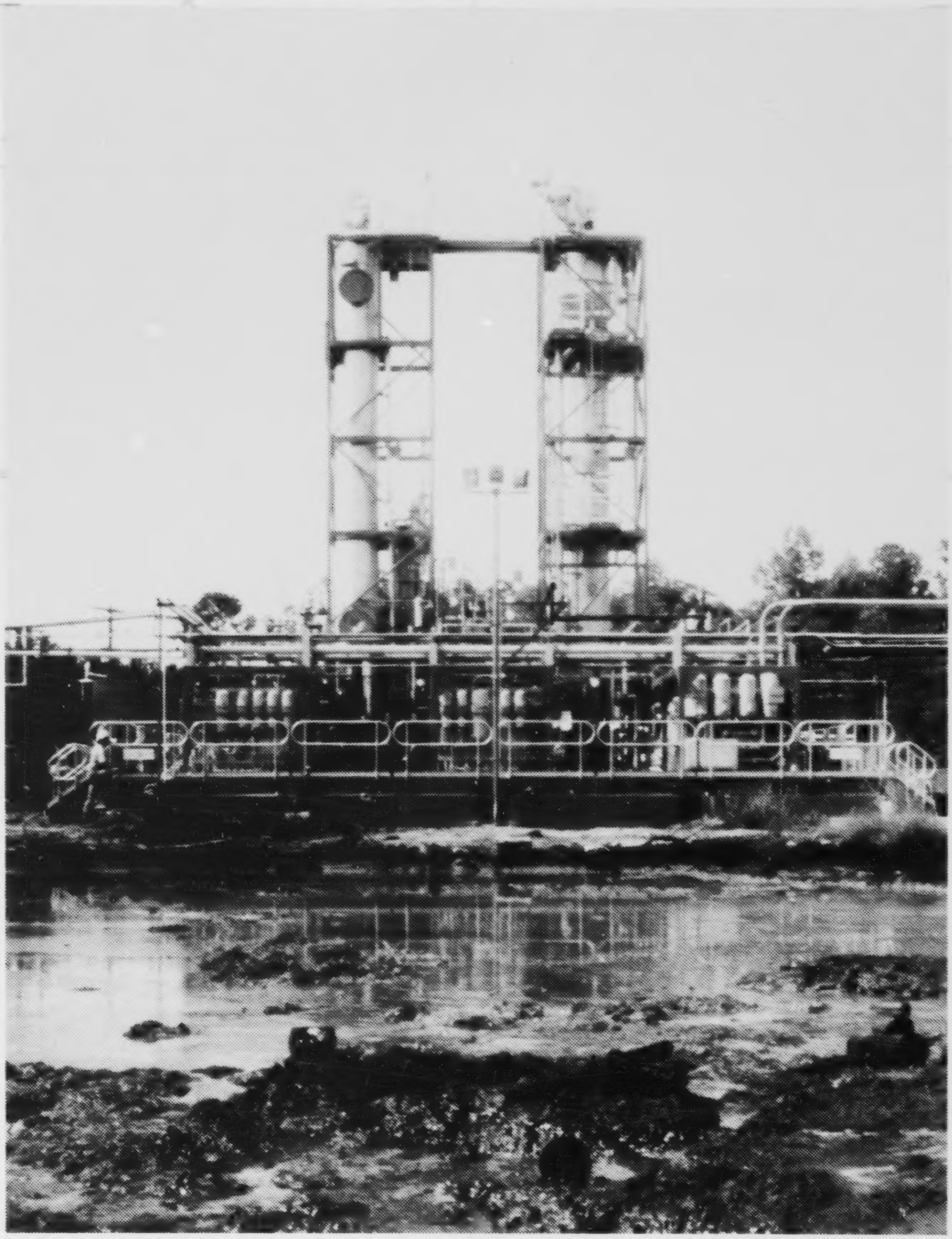


Figure 5. B.E.S.T.^{tm} sludge processing unit on location.

Source: Resources Conservation Co., Bellevue, WA

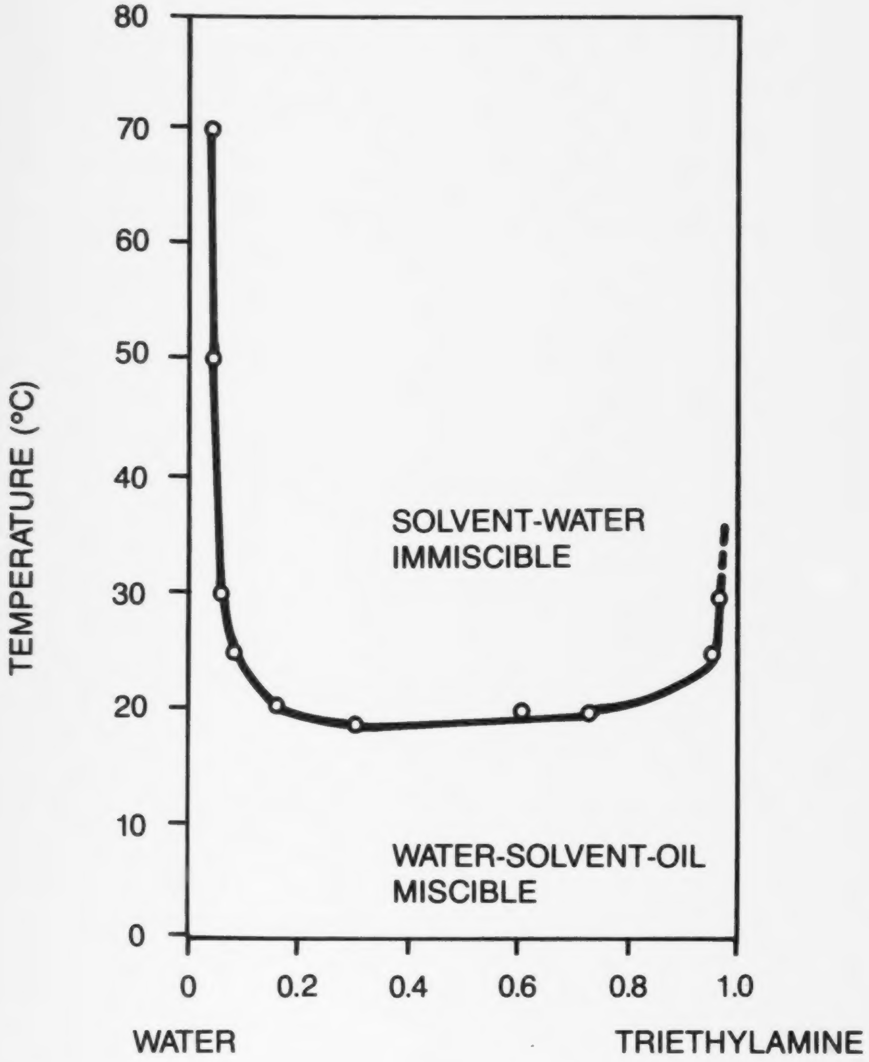


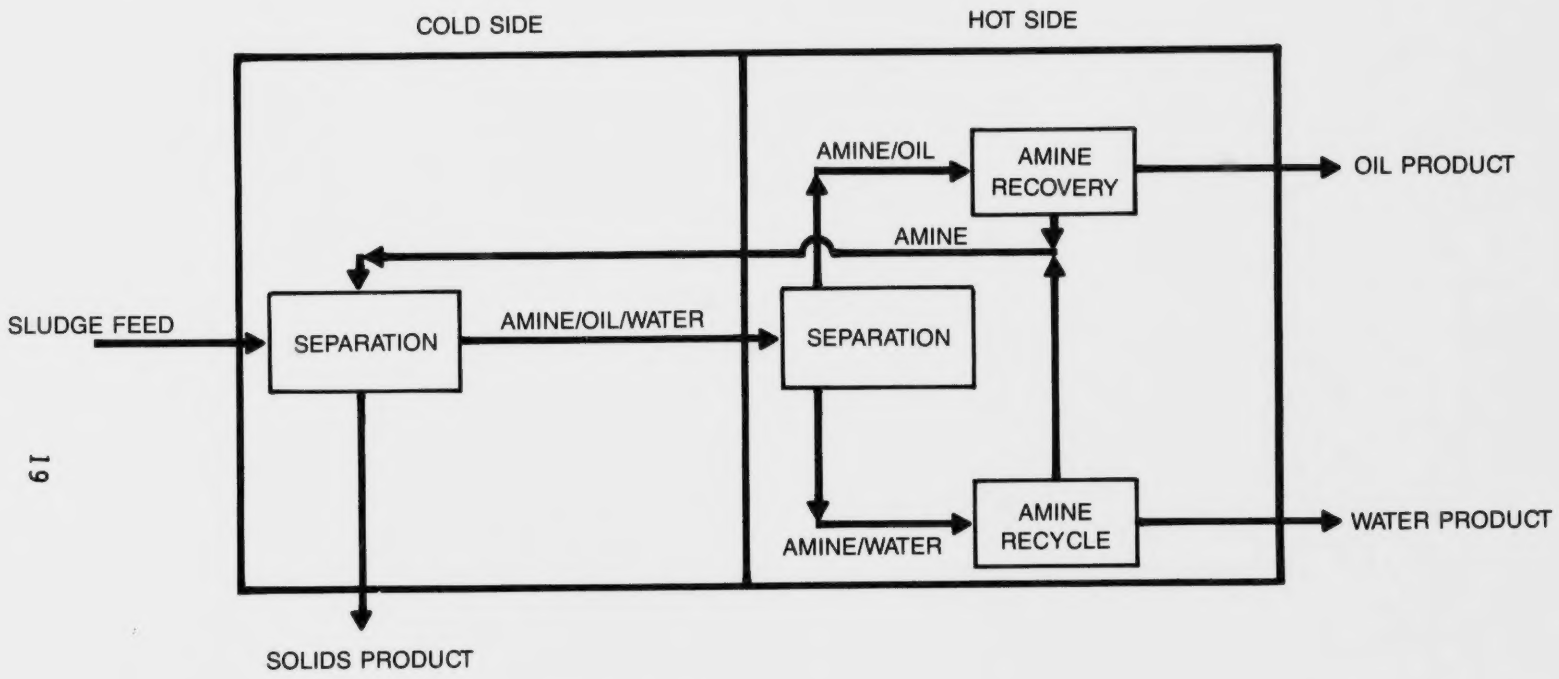
Figure 6. Triethylamine-water solubility curve.

SOURCE: RESOURCES CONSERVATION CO., BELLEVUE, WA contaminant levels. The treatment process conditions the oil for use as a feedstock in other treatment methods and so, if necessary, outside disposal is feasible. The water fraction, whose volume increases by approximately 20% due to steam condensation within the system, is able to be treated and discharged. The solids residual is powder dry and contains only traces of the oil. The capability of the process to produce a dry solids product fraction with reduced volume facilitates the management and handling of the solids material and so, if necessary, facilitates outside disposal. Metals in the solids exist in a form causing the solids to resist leaching, and they may therefore pass the EP Toxicity or Toxicity Characteristic Leaching Procedure (TCLP) tests for heavy metal concentrations. (This is not a specific process characteristic, however.)

Figure 7 schematically illustrates the two primary stages of the B.E.S.T.^{tm} process: the cold stage and the hot stage. In the cold stage sludges or soils are mixed with the solvent at temperatures below 20°C. At this temperature the liquid fractions are soluble, and suspensions and emulsions are eliminated. The solids fraction separates and is removed by a filter or centrifuge, and then dried to remove residual solvent. It is suspected that, because the amine is alkaline at a pH of approximately 10, heavy metals in the sludge are converted to hydrated oxides, which precipitate and exit the process with the solids fraction.

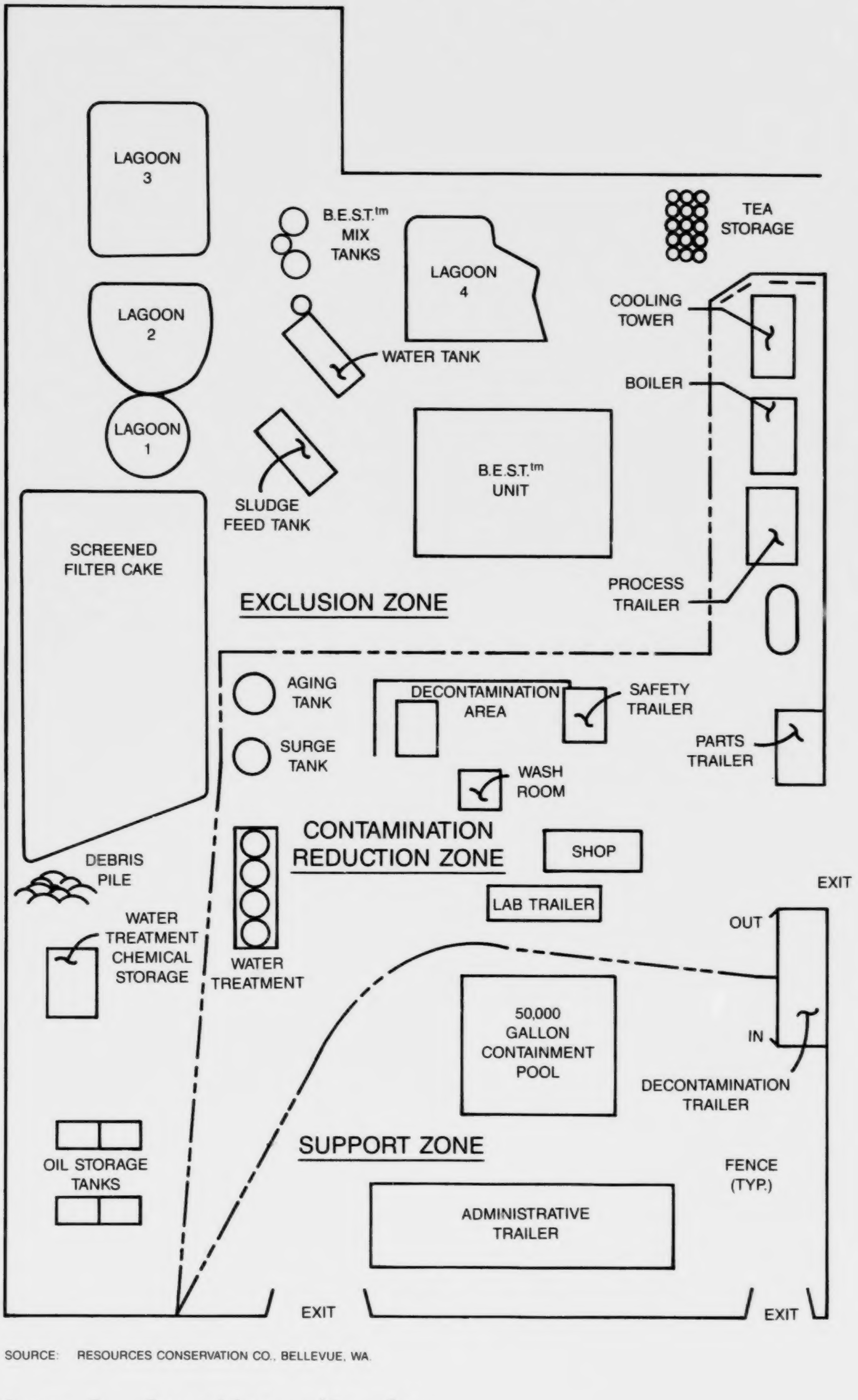
Sludge feed constraints are primarily large particle size and reactivity with the process solvent. Process performance can be influenced by the presence of detergents and emulsifiers in the feed, or of low-pH material. Low-pH material must be neutralized to prevent reactions with and loss of the TEA solvent. Detergents can result in degraded separation efficiency resulting in increased concentrations of oil and grease in the product water, and increased water content in the product oil. Emulsifiers can affect organics separation from the water fraction and can result in increased loadings on the water treatment plant, first with respect to oil and grease removal from the water, and second, for water removal from the oil.

Figure 8 illustrates the cleanup operation's site layout. During operations at the site, preprocessing treatment consisted of screening the filter cake and backfill material through a 1/4-inch hammermill, which crushed the material to the size desired for processing. Sludge from the ponds, often in excess of 1,000,000 centipoises, was pumped into a vibrating screen and placed into storage tanks to await processing. Since the sludge was highly acidic, it was neutralized with sodium hydroxide. An average feedrate of approximately forty ton/day was maintained during the test period. The oil product was discharged into an oil polisher to further separate water from the oil; the solids


COLD SIDE
HOT SIDE
SLUDGE FEED
SEPARATION
AMINE/OIL/WATER
SEPARATION
AMINE/OIL
AMINE
RECOVERY
AMINE
AMINE/WATER
AMINE
RECYCLE
OIL PRODUCT
WATER PRODUCT
SOLIDS PRODUCT

SOURCE: RESOURCES CONSERVATION CO., BELLEVUE, WA.

Figure 7. Separation diagram.


LAGOON 3
B.E.S.T.tm MIX TANKS
TEA STORAGE
LAGOON 4
COOLING TOWER
LAGOON 2
WATER TANK
BOILER
LAGOON 1
B.E.S.T.tm UNIT
SLUDGE FEED TANK
SCREENED FILTER CAKE
PROCESS TRAILER
EXCLUSION ZONE
AGING TANK
DECONTAMINATION AREA
SAFETY TRAILER
SURGE TANK
PARTS TRAILER
WASH ROOM
CONTAMINATION REDUCTION ZONE
SHOP
DEBRIS PILE
EXIT
LAB TRAILER
WATER TREATMENT CHEMICAL STORAGE
OUT
WATER TREATMENT
50,000 GALLON CONTAINMENT POOL
IN
DECONTAMINATION TRAILER
SUPPORT ZONE
OIL STORAGE TANKS
FENCE (TYP.)
ADMINISTRATIVE TRAILER
EXIT
EXIT

SOURCE: RESOURCES CONSERVATION CO., BELLEVUE, WA.

Figure 8. Operations site plan.

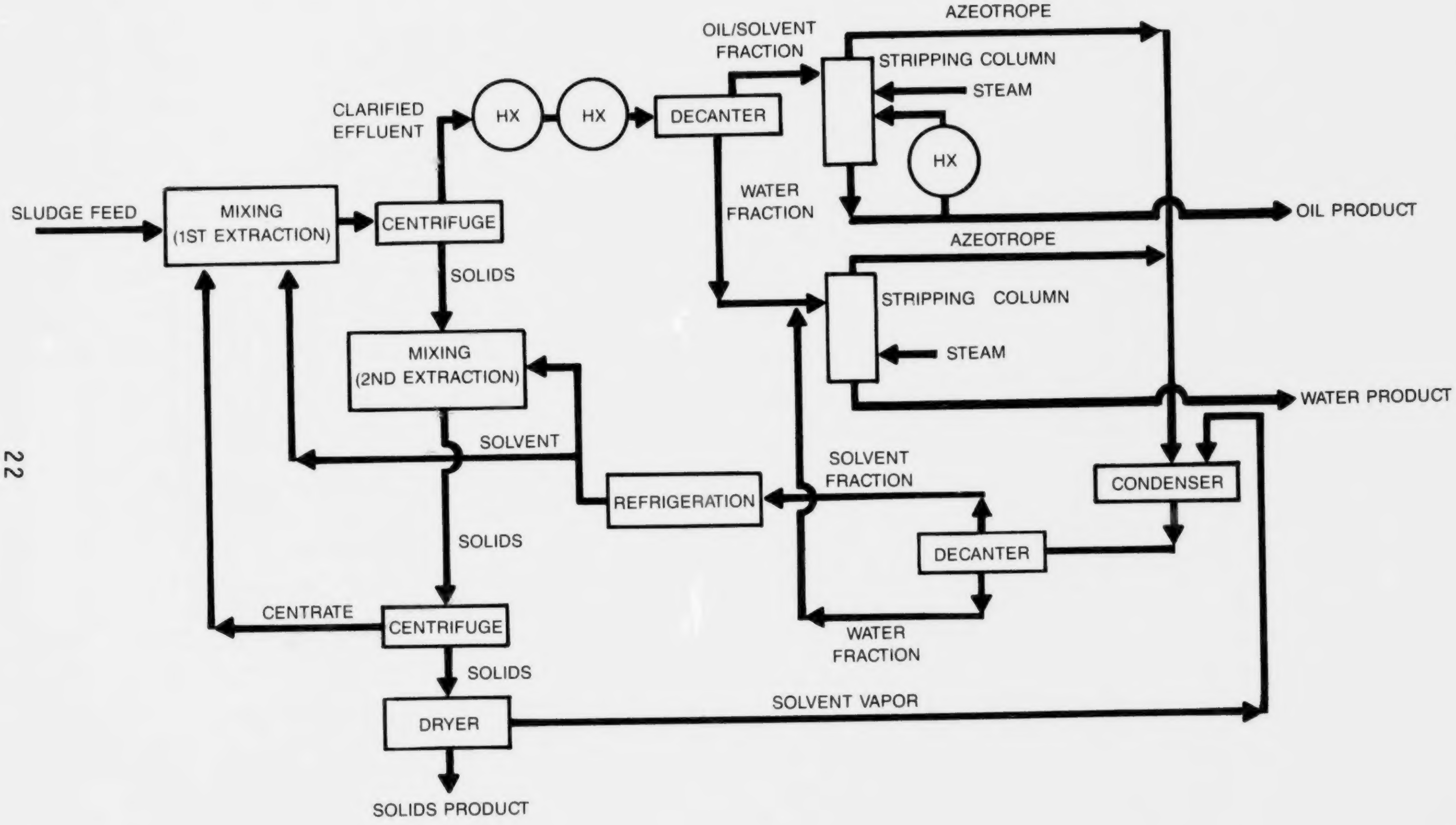
were discharged from the solids dryer through an exit chute into storage containers; and the water was further processed in an on-site treatment system.

Figure 9 diagrams the B.E.S.T.^{tm} sludge treatment process flow. The sludge is introduced to the refrigerated solvent in a mix tank, and the mixture is agitated. Sufficient residence time is provided to permit complete solvation and formation of a single liquid phase. The mixture then is sent to a solid bowl decanter centrifuge where the solid and liquid fractions are separated. The solid cake from the first centrifuge normally contains approximately 50% solids by weight. A second solids washing step is used to ensure low organics residuals in the product solids. Further washing steps can be used if even lower oil concentrations are required. The solids cake from the final extraction step is sent to a dryer.

The clarified effluent that leaves the first centrifuge is essentially free of solids and contains nearly all of the oil and water extracted from the raw sludge. This effluent, which is still cool and in solution with the amine solvent, is heated in a series of heat exchangers to a temperature above that where the solvent and water are miscible. The heated two-phase stream is passed through an oil decanter where the top fraction, which is primarily solvent but which also contains oil extracted from the raw sludge, is removed and sent to the solvent stripping column for solvent recovery. The lower fraction from the oil decanter, which contains primarily water, is sent to the water stripping column for residual solvent recovery. Oil is recovered at the bottom solvent stripping column and is discharged to temporary on-site storage. Water is recovered at the bottom of the water stripping column and is discharged to the water treatment plant.

The distillation column overheads are sent, along with the solvent vapors from the solids dryer, to a condenser from which the condensate is sent to a solvent decanter. In the solvent decanter the bottom water fraction of the condensed heterogeneous TEA azeotrope is removed and recycled through the water stripper, leaving recovered solvent. The recovered solvent is refrigerated and returned to the beginning of the process, and the cycle is repeated. Residence time within the system, from sludge entry to exit of the oil and water fractions, is approximately two hours, and for the solids fraction is approximately 30 minutes.

Posttreatment requirements for the separated fractions vary between applications. Some product oil, water, or solids upgrading may be needed depending on the intended disposition of these materials. For example, if the solids are to be landfilled, some further treatment such as fixation may be


SLUDGE FEED
MIXING (1ST EXTRACTION)
CENTRIFUGE
CLARIFIED EFFLUENT
HX
HX
DECANTER
OIL/SOLVENT FRACTION
WATER FRACTION
AZEOTROPE
STRIPPING COLUMN
STEAM
HX
OIL PRODUCT
AZEOTROPE
STRIPPING COLUMN
STEAM
WATER PRODUCT
SOLIDS
MIXING (2ND EXTRACTION)
SOLVENT
REFRIGERATION
SOLVENT FRACTION
DECANTER
WATER FRACTION
CONDENSER
SOLIDS
CENTRIFUGE
CENTRATE
SOLIDS
DRYER
SOLVENT VAPOR
SOLIDS PRODUCT

SOURCE: RESOURCES CONSERVATION CO., BELLEVUE, WA.

Figure 9. Process flow diagram.

required. PCBs can be isolated in the oil fraction and either can be chemically or thermally destroyed by subsequent treatment or used as fuel if the PCB contamination is less than 50 ppm. The product water is treated in a water treatment plant prior to discharge. The water treatment plant is a modular facility using two-stage clarification (Figure 10). The first stage consists of acidifying the water and adding a flocculent and an oil/water emulsion breaker. Then lime is added to raise the pH and aid in precipitating lead (Pb); and a contact clarifier is used to settle out sludge materials.

The B.E.S.T^{tm} sludge treatment process is operated with the use of an automatic control system that monitors process conditions and makes process adjustments as required. A process operator monitors the control system and makes additional adjustments. Samples of the feed and product streams are collected periodically and analyzed to ensure proper system operation.

Since the General Refining site was an inactive site, Resources Conservation Co. was required to supply all necessary utilities other than electricity and service water. RCC provided a mobile oil-fired boiler for steam generation, a cooling tower for cooling water, a cryogenic nitrogen (N_2) storage system, a water product treatment facility, and compressed air for process equipment operation. Figure 11 illustrates the overall process scheme, including utilities.

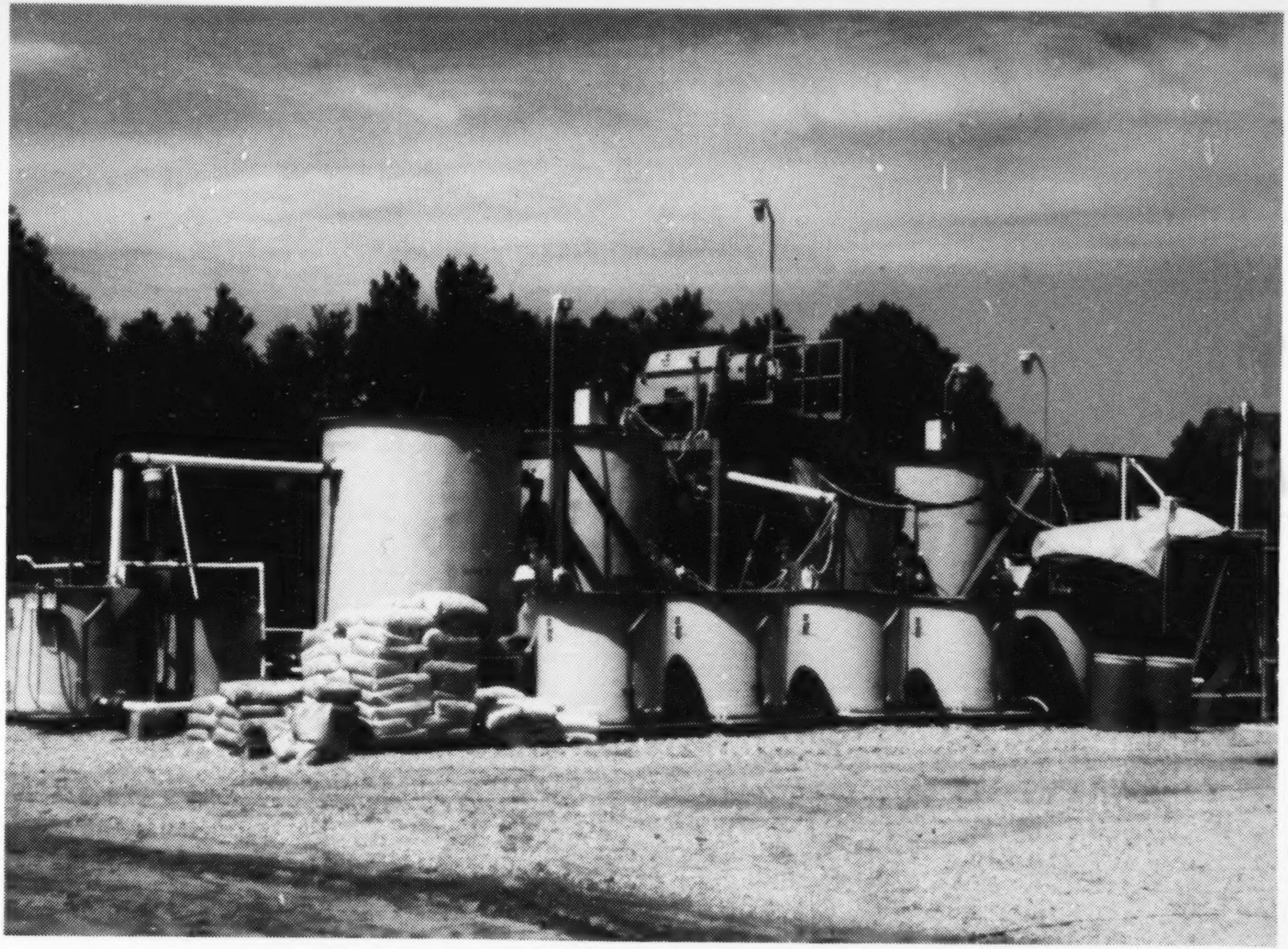
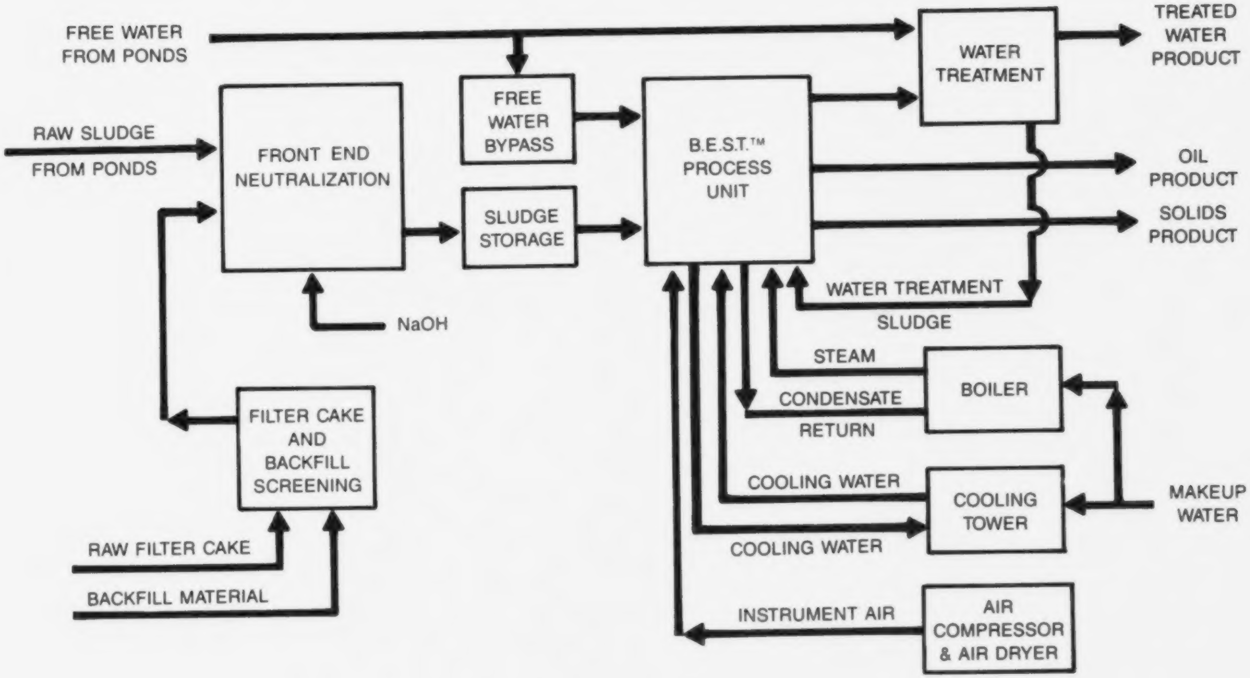


Figure 10. Water treatment plant.


FREE WATER FROM PONDS
RAW SLUDGE FROM PONDS
FRONT END NEUTRALIZATION
NaOH
FILTER CAKE AND BACKFILL SCREENING
RAW FILTER CAKE
BACKFILL MATERIAL
FREE WATER BYPASS
SLUDGE STORAGE
B.E.S.T.™ PROCESS UNIT
WATER TREATMENT
TREATED WATER PRODUCT
OIL PRODUCT
SOLIDS PRODUCT
WATER TREATMENT SLUDGE
STEAM
CONDENSATE RETURN
BOILER
COOLING WATER
COOLING WATER
COOLING TOWER
MAKEUP WATER
INSTRUMENT AIR
AIR COMPRESSOR & AIR DRYER

SOURCE: RESOURCES CONSERVATION CO., BELLEVUE, WA.

Figure 11. Process overview.

SECTION 5

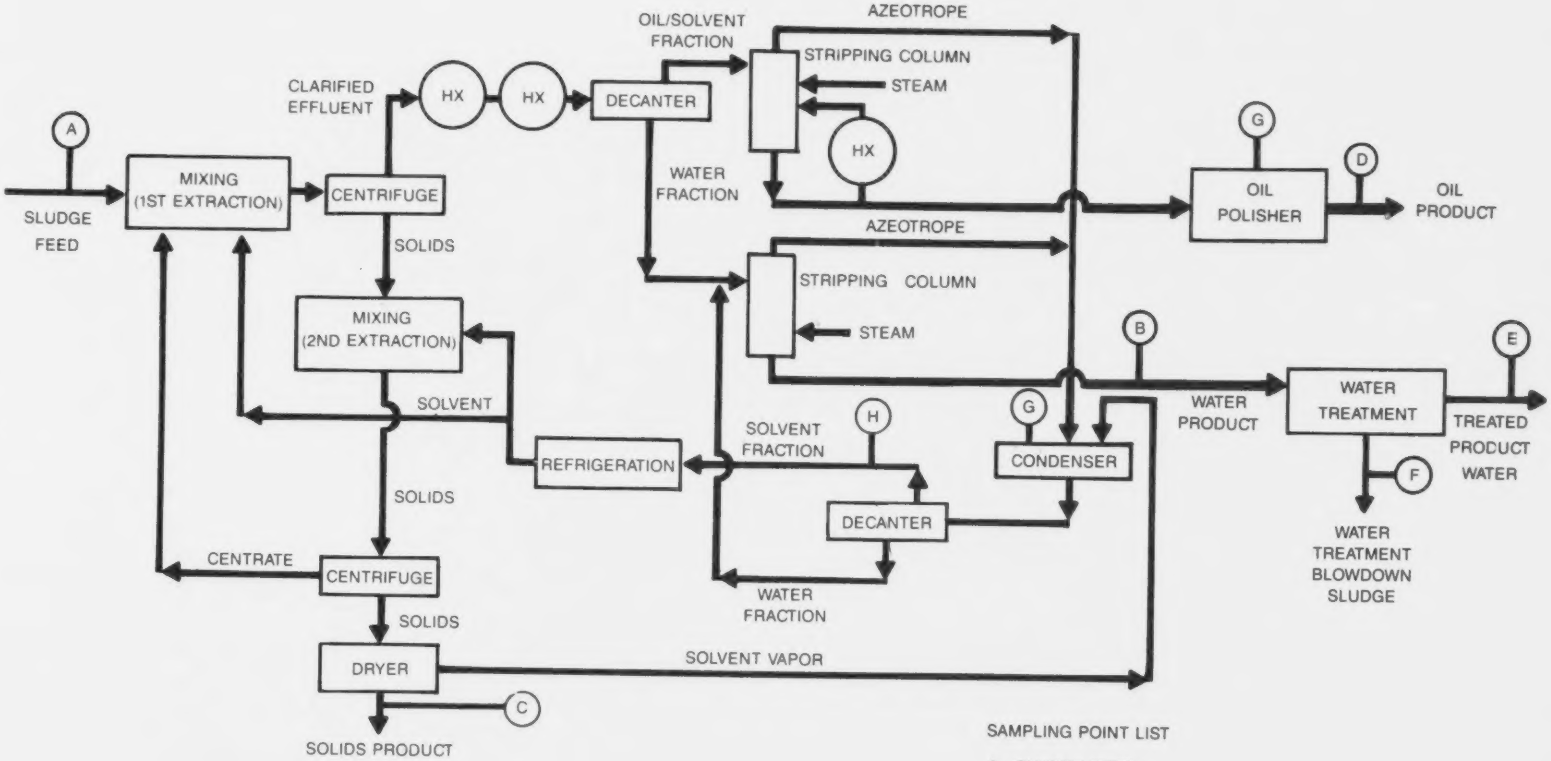
GENERAL REFINING TEST RESULTS

OPERATIONS

The General Refining site testing that was conducted in February 1987 collected data to further evaluate the phase separation efficiency of the technology, and to verify and track the fate of site contaminants. The twenty-four hour test provided samples from the feed stream, the product streams, and emission streams.

Sample locations are shown in Figure 12. The sludge feed sampling point, point A, was at the outlet of the progressive cavity pump transferring the sludge from the sludge surge tank to the processing system mixing stage. The location of this sampling point, combined with the variance in feed sludge consistency and water content raised questions as to the representativeness of the samples at this location. Since a more suitable location could not be found in the limited time allowed for the sampling program, additional samples were collected at this location to assist in determining sample variability.

Product water, sample location B, was taken where water entered the water treatment plant, just prior to the treatment plant holding tanks. The treated product water was taken at point E where treated water overflows from the turbidimeter sampling point, just prior to being pumped to the holding tank. Sampling of blowdown sludge also occurred following water treatment, at point F. Product solids were sampled at point C, from the bin where the solids dropped onto the collected solids pile. The product solids samples either were taken from the top of the triangular pile formed by the most recently discharged solids, or directly from the discharged stream if the conveyor was operating during sampling. Product oil was sampled at the outlet of the oil polisher, point D. The oil polisher is a "heater-treater" vessel that further separates water from the oil prior to oil storage. Process air emissions, point G, were sampled at the condenser vent and at the oil polisher vent. Recycled TEA was sampled at the outlet of the solvent recovery pump, point H.


A
SLUDGE FEED
MIXING (1ST EXTRACTION)
CENTRIFUGE
CLARIFIED EFFLUENT
HX
HX
DECANTER
OIL/SOLVENT FRACTION
AZEOTROPE
STRIPPING COLUMN
STEAM
HX
WATER FRACTION
G
OIL POLISHER
D
OIL PRODUCT
AZEOTROPE
STRIPPING COLUMN
STEAM
B
WATER PRODUCT
WATER TREATMENT
E
TREATED PRODUCT WATER
F
WATER TREATMENT BLOWDOWN SLUDGE
SOLIDS
MIXING (2ND EXTRACTION)
SOLVENT
REFRIGERATION
SOLVENT FRACTION
H
G
CONDENSER
DECANTER
WATER FRACTION
SOLIDS
CENTRATE
CENTRIFUGE
SOLIDS
DRYER
SOLVENT VAPOR
C
SOLIDS PRODUCT

SOURCE RESOURCES CONSERVATION CO., BELLEVUE, WA

SAMPLING POINT LIST

A - SLUDGE FEED
B - WATER PRODUCT
C - SOLIDS PRODUCT
D - OIL PRODUCT
E - TREATED PRODUCT WATER
F - WATER TREATMENT BLOWDOWN SLUDGE
G - AIR EMISSIONS
H - SOLVENT RECYCLE

Figure 12. Sample locations identification.

Table 54 in appendix B's data summary lists a cross reference of the sample identification numbers and the sample description, date, and sampling time. Approximately 162 samples were sent for analysis. The various parameters for which analyses were performed are listed in Table 6 of this report. Although consistent concentration units are generally used throughout this text, the reader is cautioned that some data are reported in mixed units.

Because of the short test preparation period and limited manpower, the test focused on the chemical composition of various streams, and not on the mechanical or electrical data that could determine throughput and economic parameters. Determination of the chemical composition of the various sample streams as a function of throughput was not stressed. Nevertheless, RCC gathered operating information and process samples before and after major separation equipment, and maintained archival records from computer control equipment as well as daily operating logs. These data were evaluated by RCC in support of engineering and cost estimating objectives. All major feed, product, and waste streams were sampled during the test period including waste feed; solids, oil, and water product streams; recycled TEA; process air emissions; and water effluent.

Table 7 presents an overall material balance of the system, using the data provided in Appendix B. The balance was developed based on the information that the product stream was composed of 27% oil, 66% water and 7% solids. Based on an average mixed sludge feed of 17,000 lb/hr, the sludge feed rate, based on an average TEA to feed ratio of 4:1, is 3,400 lb/hr (TEA free), and the average oil product stream flowrate is calculated to be 918 lb/hr, the average water product stream is 2,244 lb/hr, and the average solids product stream is 238 lb/hr. Note that the stream data are calculated values based on the analytical data and not as-measured data.

The sampling and analytical plan developed by RCC served to provide extensive information on the feed sludge and product fraction streams. The specific data are presented in the tables in Appendix B and are summarized in the following pages of this report. Since the tables presented in this report are summaries of the test data, the tables in Appendix B should be referred to as needed to obtain details of the data taken during the twenty-four hour test period.

SEPARATION PERFORMANCE

One measure of the effectivenes of the B.E.S.T.^{tm} sludge treatment process is its phase separation efficiency, i.e., determination of the percentage of oil, water, and solids found as impurities in each product fraction. Table 8 presents the

TABLE 6. TEST PARAMETERS LISTING(1)

Stream	Metals	Pb	PCBs	Volatiles	Semivolatiles	Appendix IX(2)	O&G	TEA	TCLP
Raw Sludge(3)	X	X	X	-	X	X	-	-	X
Product Solids	X	X	X	X	X	-	X	X	X
Product Oil	X	X	X	X	X	-	-	X	-
Raw Product Water	X	X	X	X	X	X	X	X	-
Treated Product Water	X	X	-	X	X	X	X	X	-
Water Treatment Blowdown Sludge	-	X	X	-	-	-	-	-	-
Air emissions(4)	-	-	-	-	-	-	-	X	-
Recycle TEA	-	-	-	-	-	X	-	-	-

(1) Source: Resources Conservation Co. Data Summary, Rev. 3, April 18, 1988, Tables 1, 6, 10, 15, and 19. See Appendix B.

(2) Appendix IX of 40 CFR 264, proposed rule, Federal Register, July 24, 1986.

(3) Indicates streams associated with Figure 12.

(4) Air emissions parameters are listed separately in Table 21 of this report.

TABLE 7. OVERALL MATERIAL BALANCE

Sludge feed (lb/hr)	Product streams (lb/hr) Oil	Solids	Water
3400 (Average)	918	238	2244

Product streams	Product stream flowrates (lb/hr) Oil	Solids	Water	TEA
Oil	908.82	--	8.08	0.46
Solids	1.93	233.24	1.19	1.48
Water	0.07	18.18	2221.56	3.14
Total	910.82	251.42	2230.83	5.08
% closure	99%	106%	99%	--

TABLE 8. B.E.S.T.^{tm} UNIT SEPARATION PERFORMANCE(1)

Separated phase fraction	Wt. % contaminant present in separated phase(2) Oil %	Water %	Solids %	TEA %
Solids	.81	<0.5	> 98	0.62
Water (Raw)	.0033	>99	0.81	0.14
Oil	99	0.88	--	<.05

(1) Source: Resources Conservation Co. Data Summary, Rev. 3, April 18, 1988, Table 24. See Appendix B.

(2) Average data. Refer to Table 17 for ranges of data.

unit separation performance data as collected during the General Refining site test evaluation. Note that these results are based on the same data as presented in Table 17. Table 8 presents average data, whereas Table 17 presents ranges of data. Results indicate that separation performance occurred as anticipated. Oil contamination present in the solids fraction was less than 1%, and very much less than 1% in the water fraction; water contamination in both the solids and oil fractions was less than 1%; and solids contamination in the water fraction also was less than 1%. These results are within the predicted values for system separation performance. Triethylamine concentrations in the product solids were higher than anticipated due to interferences during emissions sampling that adversely affected the dryer performance. The operator's logbook entries show that pressure spikes in the dryer were a result of vent gas sampling. Additional control and optimization of steam stripping of the solvent from the product streams will lower TEA concentrations in the streams.

Several of the key operating data collected during the test are included in section 9 of Appendix B and are summarized in Table 9 for reference.

CONTAMINANT SEPARATION

To determine the system's effectiveness in isolating contaminants into a specific product fraction requires an analysis of the feedstock and product streams. Tables 10 through 20 summarize the results of the feed and product stream analyses. The tables present the following data:

- Table 10. Metals analytical results
- Table 11. Total metals material balance
- Table 12. Volatile organics analytical results
- Table 13. Semivolatile organics analytical results
- Table 14. Lead and PCB analytical results
- Table 15. PCB material balance
- Table 16. Lead material balance
- Table 17. Oil and grease and Triethylamine analytical results
- Table 18. TEA material balance
- Table 19. Chlorinated Dioxins and Furans in the feed sludge
- Table 20. TCLP analytical results

TABLE 9. OPERATING DATA

	Minimum(1)	Maximum(1)	Average(1)
Mixed sludge feedrate, lb/hr	15000	20000	17000
Plant operating rate, ton/day	22(2)	70(2)	40
Triethylamine (TEA)-to -feed ratio	2:1(2)	10:1(2)	4:1
Water stripper steam rate, lb/hr	275	800	550
Dryer operating pressure, in. water	-9.6(2)	9.6(2)	2

(1) Rates approximate - interpolated from graphs in Section 9 of the Data Summary, Rev. 3, April 18, 1988. See Appendix B.

(2) Includes data spikes.

Metals Analytical Results

Metals analytical results are presented in Table 10. Only those metals detected in the sludge feed are presented. Additional metals analytical results can be found in the Appendix B tables. The data indicate that metals mostly were concentrated in the solids product fraction, which the system separation performance is intended to achieve. Further, reference to the Toxicity Characteristic Leaching Procedure (TCLP) results in Table 20 indicate that the metals in the solids were in stable forms that resisted leaching, therefore potentially qualifying the solids for land disposal techniques, or delisting. High lead (Pb) content in the oil fraction was anticipated from earlier laboratory simulations and is suspected to be caused at least in part by lead existing in the organic form in the feed and thus being extracted into the oil fraction. High lead concentrations in the oil product could present a problem in oil reuse or disposal. The reduction of metals from the raw product water stream to the water treatment system effluent demonstrates the water treatment system's capability to further reduce metal levels in the effluent.

TABLE 10. METALS ANALYTICAL RESULTS

Sludge Feed (mg/kg)		Product Fractions			
		Oil (mg/kg)	Solids (mg/kg)	Water (mg/l)	Treated Water (mg/l)
Al	330- 470	390- 1000	2300- 3210	23-91.4	33.2-38.6
As	<.6	<.6- 1.6	< .2 - <5.3	.04- <.1	<.1
Ba	160- 370	280- 910	105- 585	0.21-1.60	.082-.112
Cr	5- 7	10- 21	18- 26	.028-.155	<.01-<.02
Cu	21- 30	22- 72	100- 137	.116-.341	<.008-<.016
Fe	660- 770	1000- 2100	4000- 5710	1.68-19.9	<.052-.264
Hg	<.05	<.05	.007- <.1	<.0001-<.002	<.0002
Mn	4.2-5.5	7.5- 17	23- 29	.026-.149	<.008-.022
Ni	4- 8	<4	3.8- 10	.069-.193	.019-.028
Pb	2200-4300	4000-10200	15100-31100	33.2-230	.082-.429
Se	2- 4	<4- <10	<2.5- <8	<.05-<.08	<.05
Zn	270- 350	420- 940	839- 1260	2.35-14.5	.07-.272

Source: Resources Conservation Co. Data Summary, Rev. 3, April 18, 1988. See Appendix B.

This table is a summary of Tables 2, 7, 11, 16, and 20 of Appendix B. For statistical information concerning the number of data points, the mean, and standard deviations, refer to the Appendix B tables.

Only quantitative data are shown. Nondetected compounds are omitted.

Sludge feed nondetected metals are shown in Appendix B, Table 35.

TABLE 11. TOTAL METALS MATERIAL BALANCE

Stream	Minimum*	Maximum*	Average*
Sludge feed	1.55	2.68	2.09
Oil product	0.70	1.74	1.17
Solids product	0.71	1.32	0.99
Water product	0.02	0.10	0.08
% closure	92%	118%	107%

* Based on minimum, average, and maximum concentrations from Table 10; the Appendix B tables; and average stream rates (lb/hr) from Table 7.

A balance can be made on the product and feed stream metals content by comparing the minimum, average, and maximum detected metals concentration values, using the mass balance data generated in Table 7, and taking averages of the metals analytical results shown in Table 10. For example, the minimum sludge feed metals rate is calculated to be 456.25 mg/kg (average) as derived from the minimum metals concentrations in Table 10; and the average flow of 3400 lb/hr is taken from Table 7 to give 1.55 lb/hr minimum metals flow. Average and maximum metals flows are calculated in the same fashion. The completed metals balance is presented in Table 11.

Results also can be obtained for any single metal of interest, such as lead, by selecting from the desired metal's results, and developing a material balance on the selected metal. Table 16 illustrates such an analysis.

Volatile Organics Analytical Results

Table 12 summarizes the volatile organics analytical results. The data are insufficient to determine volatile organic separation efficiencies. However, using average concentrations shown for specific compounds, total quantities of the compound in the feed can be calculated. For example, for xylene with an average concentration in oil of 334.5 mg/kg, in solids of 35 mg/kg, and in water of 0.514 mg/l, xylene in the feed is calculated as follows:

$$(238)(35)(10^{-6})+(918)(334.5)(10^{-6})+(2244)(0.514)(10^{-6}) = 0.316554 \text{ lb/hr}$$

The amount of xylene in the oil is

$$(918)(334.5)(10^{-6}) = 0.307071 \text{ lb/hr}$$

The efficiency for xylene removal from the feed stream to the oil product fraction is calculated to be

$$(0.307071/0.316554)(100) = 97.0\%$$

Applying the same type of calculation to the toluene and ethylbenzene results yields an extraction efficiency from the feed stream to the oil product of 94.8% for toluene and 94.4% for ethylbenzene.

Semivolatile Organics Analytical Results

Table 13 summarizes the semivolatile organic compounds that were found in the product fractions in measurable concentrations. The data indicate that the semivolatiles were concentrated effectively in the oil fraction, were extracted from the solids fraction, and were present in very low

TABLE 12. VOLATILE ORGANICS ANALYTICAL RESULTS

Parameter	Sludge Feed	Product Fractions			
		Oil (mg/kg)	Solids (mg/kg)	Water (mg/l)	Treated Water (mg/l)
Acetone	-	-	2.5-3.8	5.7-7.0	2.3
Benzene	-	-	.28-.49	-	-
2-Butanone	-	-	-	1.3-<2.5	.52-.58
Chloromethane	-	-	-	.11-<2.5	-
Ethylbenzene	-	12-95	5-6.4	-	-
Methylene Chloride	-	-	.970-1	.12-<1.3	.085-<.25
Tetrachloroethene	-	-	.7-<2.4	-	-
Toluene	-	5-82	9-9.2	-	-
Trichloroethene	-	-	.32-<2.4	-	-
Triethylamine	-	-	10-81	.3-2.2	.3-.42
Xylenes	-	99-570	35	.098-.93	-

Source: Resources Conservation Co. Data Summary, Rev. 3, April 18, 1988. See Appendix B.

This table is a summary of Tables 8, 13, 17, and 21 of Appendix B. For statistical information concerning the number of data points, the mean, and standard deviations, refer to the Appendix B tables.

Only those components at or above detectable concentration limits are included. Nondetected volatiles are shown in Appendix B, Tables 37, 40, 42, 45, 48, and 51.

TABLE 13. SEMIVOLATILE ORGANICS ANALYTICAL RESULTS

Parameters	Sludge Feed (mg/kg)	Product Fractions			
		Oil (mg/kg)	Solids (mg/kg)	Water (mg/l)	Treated Water (mg/l)
N-Nitroso diphenylamine	4.8-8.3	110-150	<17-<20	<.13-<.2	<.13-<.2
Anthracene	-	29-61	-	-	-
1,2-Dichlorobenzene	<3-3.3	-	<17-<20	<.13-<.2	<.13-<.2
Dibenzofuran	-	<18-62	-	-	-
Benzoic acid	-	-	10-<97	1.2-4.6	.50-1.2
Chrysene	4.5-<7	<20-25	<17-<20	<.13-<.2	<.13-<.2
Fluoranthene	<3-3.7	-	<17-<20	<.13-<.2	<.13-<.2
Fluorene	3.4-<7	120-180	<17-<20	<.13-<.2	<.13-<.2
Naphthalene	22-30	290-370	2.3-<20	<.13-<.2	<.13-<.2
2-Methylnaphthalene	36-50	1200-1700	2.4-<20	<.13-<.2	<.13-<.2
Acenaphthene	-	60-92	-	-	-
Phenanthrene	13-17	250-360	2.1-2.5	<.13-<.2	<.13-<.2
Phenol	<3-<7	40-63	<17-<20	.38-1.9	1.2-1.9
4-Methylphenol	-	<18-85	3.1-<20	.34-.73	.45-.73
4-Chloro 3-Methyl phenol	-	-	1.9-<20	<.13-<.2	<.13-<.2
2,4-Dimethylphenol	-	-	-	.05-<.13	<.05-<.13
Bis (2-ethylhexyl) phthalate	<3-49	<18-180	5.2-6.6	<.13-<.2	<.13-<.2
Butylbenzylphthalate	-	-	2.8-<20	<.13-<.2	<.13-<.2
Pyrene	<3-3.6	23-43	<17-<20	<.13-<.2	<.13-<.2

Source: Resources Conservation Co. Data Summary, Rev. 3, April 18, 1988. See Appendix B

This table is a summary of Tables 3, 9, 14, 18, and 22 of Appendix B. For statistical information concerning the number of data points, the mean, and standard deviations, refer to the Appendix B tables.

Only those compounds at or above detectable concentration limits are included. Nondetected semivolatiles are shown in Appendix B, Tables 36, 38, 41, 43, 46, 49, and 52.

concentrations in the water fraction, as predicted by laboratory tests.

The table shows that the product water fraction contained three semivolatile compounds in notable amounts: two phenolic compounds and benzoic acid. The probable reason that these compounds did not completely extract into the oil fraction is their similar solubility characteristics at the high pH of the samples. As these compounds were partially ionized, the ionic form of the molecules would tend to separate into the water fraction during the decantation step of the process.

Note that the amount of 2-methylnaphthalene, naphthalene, N-nitrosodiphenylamine, pyrene, and fluorene were found in the oil product in much higher quantities than would be predicted based on the raw sludge analysis and the fact that the raw sludge feed was approximately 27% oil. This excess concentration is due to the addition of diesel to the product oil as a viscosity reducer.

Lead and PCB analytical results

Table 14 presents the lead and PCB analytical results derived from the test period. The data indicate that lead from the sludge was distributed about equally between the oil and solids fractions; PCBs were primarily concentrated into the oil fraction, with a trace found in the solids fraction and essentially none detected in the water fraction. Concentrations of PCB in the oil product and reductions of PCB in the solids and water products are among the separation and isolation advantages of the B.E.S.T.^{tm} technology. PCB partitioning to the oil fraction might have been even higher had it not been necessary to dilute the oil product with diesel fuel to decrease the sludge's viscosity. Also, only five samples were analyzed for PCBs, with high standard deviations in the data, resulting in PCB mass balances that were lower than indicated by compositional analysis, as shown in Table 15.

Lead was found to have separated between the oil and solids fractions. Since General Refining had processed waste oils from gasoline service stations, organic tetraethyl lead was suspected to be prominent in the contaminants. It is suspected that organic lead was extracted preferentially into the oil fraction, while other lead complexes formed oxides and were separated into the solids fraction. A lead material balance is presented in Table 16.

Oil and Grease and Triethylamine Analytical Results

Oil and Grease (O&G) and triethylamine (TEA) analytical results are presented in Table 17. TEA concentrations in each product stream were higher than laboratory simulation

TABLE 14. LEAD AND PCB ANALYTICAL RESULTS

Parameter	Sludge Feed (mg/kg)	Product Fractions			Water Treatment	
		Solids (mg/kg)	Oil (mg/kg)	Water (mg/l)	Treated Water (mg/l)	Blowdown Sludge (mg/l)
Pb	2200-7400	4500-31100	4000-10200	33.2-230	.082-.429	72-150
(mean)	3480	21280	6654	108.9	.162	111
PCBs	1.8-11.4	0.37-<1.7	8.2-11	<.006-<.01	-	<.01
(mean)	5.94	--	9.28	--	-	--

Source: Resources Conservation Co. Data Summary, Rev. 3, April 18, 1988. See Appendix B.

This table is a summary of Tables 28 and 29A, B, C, D, and E of Appendix B. For statistical information concerning the number of data points, the mean, and standard deviations, refer to the Appendix B tables.

Nondetected PCBs and pesticides are shown in Appendix B, Tables 39, 43, 47, 50, and 53.

TABLE 15. PCB MATERIAL BALANCE

Stream	Minimum*	Maximum*	Average*
Sludge feed	0.00612	0.03876	0.02020
Oil product	0.00747	0.01002	0.00845
Solids product	0.00009	0.00043	0.00026
Water product	0.00001	0.00002	0.00002
% closure	124%	27%	43%

* Based on minimum, average, and maximum concentrations from Table 14 and average stream rates (lb/hr) from Table 7.

TABLE 16. LEAD MATERIAL BALANCE

Stream	Minimum*	Maximum*	Average*
Sludge feed	7.48	25.16	11.83
Oil product	3.64	9.29	6.06
Solids product	1.13	7.28	5.35
Water product	0.07	0.51	0.24
% closure	65%	68%	98%

* Based on minimum, average, and maximum concentrations from Table 14 and average stream rates (lb/hr) from Table 7.

TABLE 17. OIL AND GREASE AND TRIETHYLAMINE ANALYTICAL RESULTS

Parameter	Sludge Feed	Product Fractions			
		Solids	Oil	Water	Treated Water
O&G (mg/l)	--	.583-10000	-	14-52	77-113
TEA (ppm)	--	<100-9700	<500	1100-1800	380-760

Source: Resources Conservation Co. Data Summary, Rev. 3, April 18, 1988. See Appendix B.

This table is a summary of Tables 26 and 27 of Appendix B.

Refer to Table 8 for average data.

predictions. This was not unexpected since interferences during emissions testing affected TEA volatilization and resulted in high TEA residuals.

Table 18 provides a TEA material balance. The consumption of TEA during processing at the General Refining site was higher than desired mainly due to fugitive losses from the centrifuge seals and seals in the rotating shafts of the solids dryer. RCC recognized that fugitive losses were higher than desired, and they took corrective actions to modify the seals on the centrifuges and dryer. It is expected that the sealing modifications will result in reduced fugitive emissions and significantly reduced TEA consumptions.

The Table 18 data indicate that the makeup rate of TEA per ton of sludge feed, based on an average sludge feedrate of 3400 lb/hr, is about 16 pounds (2 1/2 gallons) of TEA per ton of sludge.

RCC's laboratory simulations predict that, based on a 70 ton/day feedrate, 0.3 pounds of TEA per day will exit the process in the product streams. TEA fugitive losses of 0.2 lb/day are estimated based on equipment sealing modifications. This represents a makeup rate of 2.5 pounds (approximately 1/2 gallon) of TEA per ton of sludge, as compared to the 16 pounds per ton derived during the test.

Chlorinated Dioxins and Furans

Table 19 shows the analytical results of tests for chlorinated dioxins and furans in a sample of the raw sludge feed. The analysis was conducted using EPA SW846 Method 8280, with results indicating that chlorinated dioxins and furans were not detected.

Toxicity Characteristic Leaching Procedure (TCLP) Analytical Results

Table 20 presents the TCLP analyses that were conducted on the product solids to determine the effect of the B.E.S.T.^{tm} process on contaminant leachability. As the data show, good improvement was achieved in lowering the leachability of most of the metals and of all organics. The feed sludge TCLP results have been omitted from the table since the use of the TCLP procedure to compare the feedstock leachability to the product solids leachability may not be dependable because of the difference between the sample matrices. Also, the solids constituted only seven percent of the raw sludge and the sludge was found to be hydrophobic. The hydrophobic character of the sludge may have limited the capability of the TCLP test to leach metals from the sludge sample. These factors could have affected the raw sludge sample characterization when evaluated

TABLE 18. TEA MATERIAL BALANCE

Stream	Average flowrate*
TEA makeup	28
Oil product	0.46
Solids product	1.48
Water product	3.14
Process air emissions	0.31
% closure	19%

* Based on average stream concentrations from Tables 8 and 21, flowrates from Table 7, and a TEA makeup rate of 2 drums/day.

TABLE 19. CHLORINATED DIOXINS AND FURANS IN THE FEED SLUDGE

Parameter	Results	Units	Reporting Limits
Tetrachlorodibenzo-p-dioxins	ND	ng/g	0.55
Pentachlorodibenzo-p-dioxins	ND	ng/g	1.5
Hexachlorodibenzo-p-dioxins	ND	ng/g	0.72
Heptachlorodibenzo-p-dioxins	ND	ng/g	1.0
Octachlorodibenzo-p-dioxins	ND	ng/g	7.1
Tetrachlorodibenzofurans	ND	ng/g	0.32
Pentachlorodibenzofurans	ND	ng/g	1.1
Hexachlorodibenzofurans	ND	ng/g	1.7
Heptachlorodibenzofurans	ND	ng/g	1.0
Octachlorodibenzofurans	ND	ng/g	0.32

Source: Resources Conservation Co. Data Summary, Rev. 3, April 18, 1988, Table 5. See Appendix B.

TABLE 20. TCLP ANALYTICAL RESULTS

Parameter	Solids Product (mg/l)	Regulatory level (mg/l)
Al	1.0-2.4	
As	<.02-<.06	5
Ba	<.03-<.05	100
Cr	<.05-<.1	5
Cu	<.03-<.06	
Fe	1.6-7.1	
Pb	4.0-12	5
Mn	.43-.61	
Hg	<.001-<.002	0.2
Ni	<.2-<.4	
Se	<.008-<.08	1
Zn	21-33	
Benzene	<.025-<.05	0.07
Ethylbenzene	ND-.52	
4-Methyl-2-pantanone	<.05-.059	
Phenol	.01-.056	14.4
4-Methylphenol	.029-.071	
2,4-dimethylphenol	.0086-.019	
Trichloroethene	<.025-.030	
Toluene	.09-.56	14.4
Xylenes	.045-.72	

Source: Resources Conservation Co. Data Summary, Rev. 3, April 18, 1988. See Appendix B.

For statistical information concerning the number of data points, the mean, and standard deviations, refer to the Appendix B tables.

Only quantitative data are shown. Nondetected compounds are omitted. Nondetected compounds are shown in Appendix B, Tables 42 and 43.

Table 4 of Appendix B shows the sludge feed TCLP extract results.

ND Not detected

using the TCLP procedure. Nevertheless, the more important results on the solids indicate possible acceptability for disposal. As mentioned earlier in this report, the solids TCLP results indicate that the metals were stabilized and resisted leaching.

Air Emissions

Air emissions results are listed in Table 21. Air emissions were monitored at two sampling locations: the condenser vent and the oil polisher, an oil/water reduction system vent. Five parameters were tested: benzene, mercury, toluene, triethylamine, and xylene.

Recycle Triethylamine

At the conclusion of the processing at the General Refining site, samples were taken of the TEA recycle inventory and analyzed for volatile organics to determine if the solvent was contaminated during operation. Table 22 shows the results of the recovered TEA analysis. Although the level of contaminants found in the TEA at the General Refining site indicate that solvent degradation had not occurred, for future tests volatile contaminants in the recovered solvent must be evaluated for each test program to determine the effect of the contaminants on solvent recovery and process efficiency. In any case, the TEA solvent can be reused directly if it is not adversely contaminated, or treated to remove any undesirable contaminants.

COMPARISONS OF FIELD AND LABORATORY DATA

Performance of the B.E.S.T.^{tm} solvent extraction technology can be determined empirically by laboratory-scale simulations of the process, followed by analytical testing of the product streams from the laboratory equipment. Prior to full-scale operation, a laboratory-scale test of the intended process is performed to determine relative process separation efficiencies and to anticipate the ultimate quality of the product fractions. Resources Conservation Co. has conducted many laboratory tests and developed correlations to which data from full-scale operations, such as the General Refining site, can be compared.

Appendix B contains several tables of comparisons of RCC's laboratory-scale test results on various sludges, as compared to the results achieved in the operation of the prototype full-scale commercial facility at the General Refining site. The data contained in the Appendix B tables are summarized in the following tables of this report:

TABLE 21. AIR EMISSIONS RESULTS

	Run 1	Run 2	Run 3	Run 4	Average
Condenser Exhaust					
Concentration (ppmvd)					
Benzene	321	321	339	311	323
Mercury	<0.00496	<0.00496	<0.00496	<0.00496	<0.00496
Toluene	164	144	145	132	146
Triethylamine	22,560	13,235	29,928	29,003	23,682
Xylene	200	182	191	161	184
Emission Rate (lb/hr)					
Benzene	0.00127	0.00127	0.000926	0.00108	0.00114
Mercury	<0.000000052	<0.000000041	<0.000000042	<0.000000037	<0.000000043
Toulene	0.000769	0.000676	0.000469	0.000540	0.000614
Triethylamine	0.0985	0.0492	0.131	0.0103	0.0954
Xylene	0.00108	0.000983	0.000710	0.000763	0.000884
Oil Polisher Outlet					
Concentration (ppmvd)					
Benzene	39.3				
Mercury	<0.0677				
Toluene	1502				
Triethylamine	20130				
Xylene	8271				
Emission Rate (lb/hr)					
Benzene	0.00473				
Mercury	<0.00000210				
Toluene	0.0214				
Triethylamine	0.314				
Xylene	0.135				

Source: Resources Conservation Co. Data Summary, Rev. 3, April 18, 1988, Table 23. See Appendix B.

TABLE 22. RECYCLE TRIETHYLAMINE HAZARDOUS SUBSTANCE LIST VOLATILES ANALYTICAL RESULTS

Parameter	Concentration (mg/kg)
Benzene	220
Chloroform	210
Ethylbenzene	310
Methylene chloride	1100
Toluene	1800
Total Xylenes	1600

Source: Resources Conservation Co., B.E.S.T.^{tm} Cleanup Performance Test Results, Volume 6, Section 26, April 8, 1987.

- Table 23. Comparison of General Refining laboratory data to full-scale processing data
- Table 24. Laboratory phase separation data for General Refining sludge vs. other materials
- Table 25. Laboratory contaminant partitioning data for General Refining sludge vs. other materials

Table 23 presents the data gathered from laboratory simulations of the General Refining site waste along with the results obtained during actual process operation.

Sludges from the General Refining site were taken to RCC's laboratory and processed through the laboratory-scale equipment. These results are presented in Table 23, and are compared to results of analyses of the sludge and product streams taken from the full-scale, on-site operation. The comparison shows good correlations between the two groups of data. Specifically, for similar product feed compositions, the actual full-scale results show product stream contamination levels to be lower than those predicted by the laboratory simulations. This indicates that the prototype full-scale operation achieved better separations than were predicted by laboratory results.

Table 24 presents comparisons of laboratory data on the General Refining site sludge to laboratory data obtained on other sludge types. These data are ranges only. The specific data are included in Appendix B.

TABLE 23. COMPARISON OF GENERAL REFINING LABORATORY DATA TO FULL-SCALE PROCESSING DATA(1)

Composition	Laboratory Data Raw Sludge	Laboratory Data Phase Fractions Oil	Laboratory Data Phase Fractions Water	Laboratory Data Phase Fractions Solids	Full-Scale Data Raw Sludge	Full-Scale Data Phase Fractions Oil	Full-Scale Data Phase Fractions Water	Full-Scale Data Phase Fractions Solids
Oil (%)	36	84	0.017	5.7	27	99	0.0033	0.81
Water (%)	56	16(2)	>99	-	66	0.88	>99	<0.5
Solids (%)	8	(3)	-	94	7	(4)	0.81	>98

(1) Source: Resources Conservation Co. Data Summary, Rev. 3, April 18, 1988, Table 25. See Appendix B.

(2) Bottom sediment and water (BS&W).

(3) Particulates are included in BS&W.

(4) Not measured.

(5) Data is reported on a TEA-free basis.

TABLE 24. LABORATORY PHASE SEPARATION DATA FOR GENERAL REFINING SLUDGE VS. OTHER MATERIALS(1)

COMPOSITION	General Refining Data Raw Sludge	General Refining Data Phase Fractions Oil	General Refining Data Phase Fractions Water	General Refining Data Phase Fractions Solids	Other Sludge Data(2) Raw Sludge	Other Sludge Data(2) Phase Fractions Oil	Other Sludge Data(2) Phase Fractions Water	Other Sludge Data(2) Phase Fractions Solids
Oil (%)	36	-	0.017	5.7	6.5-22	-	0.0097-0.37	.2-1.5
Water (%)	56	16(3)	-	-	45-87	<2-6	-	-
Solids (%)	8	(4)	-	-	5-49	.29-.69	<0.001-.044	-

(1) Source: Resources Conservation Co. Data Summary, Rev. 3, April 18, 1988, Table 30. See Appendix B.

(2) Comparisons of slop oil emulsion, DAF float, and API bottoms sludges.

(3) Bottom sediment and water (BS&M).

(4) Particulates are included in BS&W.

RCC processed sludge from the General Refining site through their laboratory equipment and obtained data from other API sludges also processed through the laboratory equipment. These results are compared in Table 24. The data demonstrate that better separations were achieved on the API sludges than on the General Refining sludge, suggesting that full-scale processing of API sludges would produce better separations and separation efficiencies than were achieved in the General Refining operation. RCC attributes the less efficient separations of the General Refining materials to the presence of compounds such as detergents and emulsifiers that were found in the General Refining sludges, but that usually are not found in API sludges. These agents can have detrimental effects on system separation efficiencies.

Table 25 compares partitioning data derived from laboratory-scale tests on the General Refining sludge for selected parameters such as oil and grease, lead, chromium, and EP toxicity lead and chromium to data from laboratory-scale tests on other sludges. Note the high lead concentrations in the General Refining sludge.

The comparisons in Tables 23, 24, and 25 indicate that treatability evaluations can be made based on laboratory-scale testing. RCC suggests that laboratory-scale testing be done prior to full-scale operation to determine anticipated separation efficiencies and product fraction quality. To date the laboratory-scale data has provided a reliable means to predict full-scale operational results, and as such can be expected to provide reliable treatability indications. Continued comparisons of laboratory-scale data to full-scale data will confirm further the reliablity of laboratory-scale testing for use in treatability studies.

From the overall data presented in this section, it can be concluded that the solvent extraction system did efficiently separate the General Refining sludge into its three product fractions and that organic contaminants concentrated mostly into the oil fraction, metals concentrated mostly into the solids fraction with partial partitioning into the oil fraction, and the water fraction can be pretreated for discharge into an industrial or publicly owned treatment works.

TABLE 25. LABORATORY CONTAMINANT PARTITIONING DATA FOR GENERAL REFINING SLUDGE VS. OTHER MATERIALS(1)

Composition	General Refining Data			Other Sludge Data(2)		
	Raw Sludge	Phase Fractions		Raw Sludge	Phase Fractions	
		Oil	Solids		Oil	Solids
Oil and Grease (%)	5.7	-	-	0.2-3.3	-	-
Lead (mg/kg)	3223	6654	22809	1.4-1018	<1-27	220-4000
Chromium (mg/kg)	6.2	15	20.8	1.65-1290	0.7-400	57-10800
EP Tox lead (mg/kg)	6.4	-	-	0.14-0.74	-	-
EP Tox chromium (mg/kg)	<0.1	-	-	.02-1.3	-	-

(1) Source: Resources Conservation Co. Data Summary, Rev. 3, April 18, 1988, Tables 31, 32, 33, and 34. See Appendix B.

(2) Comparisons of slop oil emulsions, DAF float, API bottoms, and blind samples sludges.

SECTION 6

QUALITY ASSURANCE/QUALITY CONTROL

To ensure that adequate quality control measures were established to direct the sampling and analytical activities, RCC and USEPA Region X developed the sampling and analysis plan shown in Appendix A, and instituted a sampling program covering the last two days of plant operation.

A program to obtain quality data was developed that included:

- Custody seal requirements
- Chain-of-Custody record sheets
- Contract Laboratory Program (CLP) communication record sheets
- Chain-of-Custody tabulation forms
- Sample control requirements, including sample identification, chain-of-custody procedures, sample custody, field custody procedures, transfer of custody and shipments, and laboratory custody procedures
- Document control requirements, including serialized documents, project logbooks, field data records, sample identification documents, chain-of-custody records, analyst logbooks, instrument and sample entry logbooks, photographs, corrections to documentation, constancy of documentation, document numbering system and inventory procedures, Emergency Response Cleanup Services (ERCS) files, Program Manager office files, reports, and litigation documents

The sampling plan developed by Region X and RCC (Appendix A) includes a project description and project objectives. The plan describes sample locations, explains anticipated problems and data interferences, develops a sample frequency matrix, and outlines the analytical methodologies anticipated to be used for each sample.

There was insufficient time to develop a separate detailed QA/QC plan. However, an EPA Contract Laboratory Program (CLP) analytical laboratory was chosen, which therefore had an EPA-approved CLP QA/QC program in place to define the required data quality objectives; establish the analytical and corrective action procedures; define and perform internal QC checks; and develop data reduction, validation, and reporting procedures.

RCC's data quality objectives are stated in their sampling and analysis plan. The objectives during the test were as follows:

- Conduct a broad evaluation of the performance of the process concept, including environmental emissions.
- Identify and record important process parameters.
- Determine the composition of the sludge feed and product oil, water, and solids streams by analysis of randomly taken samples.
- Evaluate the system performance from the data taken during the test.

The plan describes the sampling locations, presents a matrix showing the number of samples to be taken at each location, lists the times that each sample is to be taken, shows the analytical methods to be used for each test, lists the container types for sampling handling, and establishes the requirements for field duplicates and for field blanks. Sample containers were obtained from the EPA sample bottle depository in Miramar, California. Table 26 shows the quantity of samples and field duplicates taken during testing.

RCC performed the sampling activities, with the exception of emissions testing which was done by Entropy Environmentalists, Inc. The analytical work was performed by Enseco, Inc. Rocky Mountain Analytical Laboratory in accordance with EPA protocols established in the EPA document SW846. Sample collection and identification, sample volumes, handling, in-house preservation, chain-of-custody, and transportation techniques and methods were identified and recorded by RCC. The sampling and analysis work met the objectives as outlined in the plan, including collection of the requisite number of duplicate field samples and field blanks.

Enseco's laboratories operate under a rigorous QA/QC program designed to ensure the generation of scientifically valid, legally defensible data by monitoring every aspect of

TABLE 26. SAMPLE QUANTITIES AND FIELD DUPLICATES

Stream	Metals	PCBs	TCLP	Appendix IX	VOA	BNA	TEA	O&G
Sludge feed	16 (2)	16 (1)	2 (0)	1 (0)	--	4 (1)	--	--
Product solids	8 (3)	3 (0)	8 (2)	--	2 (1)	3 (1)	2 (1)	8 (2)
Product oil	9 (1)	4 (1)	--	--	4 (1)	4 (1)	4 (1)	--
Product water	8 (1)	3 (1)	--	1 (0)	2 (1)	1 (0)	2 (0)	2 (1)
Treated product water	8 (1)	2 (1)	--	1 (1)	2 (0)	2 (1)	2 (1)	2 (1)

Source: Resources Conservation Co. Data Summary, Rev. 3, April 18, 1988. See Appendix B.

This table is a summary of Tables 1, 6, 10, 15, and 19 of Appendix B.

Quantity in parenthesis is the number of duplicate field samples taken.

laboratory operations. Routine QA/QC procedures include the use of approved methodologies, independent verification of analytical standards, use of duplicate laboratory control samples to assess the precision and accuracy of the methodology on a routine basis, and a rigorous system of data review. Data sheets contain a listing of the parameters measured in each test, the analytical results, the Enseco reporting limits, and regulatory limits where established.

Enseco's quality control program is based upon monitoring the precision and accuracy of an analytical method by analyzing a set of duplicate Laboratory Control Samples (LCS) at frequent well-defined intervals (Tables 27 and 28). An LCS is a well-characterized matrix that is spiked with target compounds at 5 to 100 times the reporting limit, depending upon the methodology being monitored. The purpose of the LCS is not to duplicate the sample matrix, but rather to provide an interference-free, homogeneous matrix from which to gather data to establish control limits. These limits are used to determine whether data generated by the laboratory on any given day meets quality control objectives.

Control limits for accuracy (percent recovery) are based on the historical average percent recovery, ±3 standard deviation units. Control limits for precision (relative percent difference) range from 0 (identical duplicate LCS results) to the historical average relative percent difference, + 3 standard deviation units. These control limits are fairly narrow based on the consistency of the matrix being monitored and are updated on a quarterly basis. For multi-analyte determinations, eighty percent of the accuracy and precision measurements must be within control limits for the QC lot to be considered acceptable.

For organic analyses an additional control measure is taken in the form of a Surrogate Control Sample (SCS). The SCS is a control sample spiked with surrogate standards, which is analyzed with every analytical lot (Table 29). The recovery of the SCS is charted in exactly the same manner as described for the LCS, and provides a daily check on the performance of the method.

Accuracy for LCS and SCS is measured by Percent Recovery.

$$\%\ \text{Recovery} = \frac{\text{Measured Concentration}}{\text{Actual Concentration}} \times 100$$

TABLE 27. LABORATORY CONTROL SAMPLE REPORT: GAS CHROMATOGRAPHY/MASS SPECTROMETRY

Analyte*	Concentration Spiking	Measured LCS1	Measured LCS2	Accuracy (%) LCS1	Accuracy (%) LCS2	Accuracy (%) Limits	Precision (RPD) LCS	Precision (RPD) Limits
Pentachlorophenol	100	69.1	69.1	69	69	9-103	0.0	50
Phenol	100	60.6	60.3	61	60	12-89	0.5	42
2-Chlorophenol	100	75.7	70.1	76	70	27-123	7.7	40
4-Chloro-3-cresol	100	71.4	71.1	71	70	23-97	0.4	42
4-Nitrophenol	100	69.1	75.8	69	76	10-80	9.2	50
1,2,4-Trichlorobenzene	50	37.4	32.8	75	66	39-98	13.1	28
Acenaphthene	50	39.8	37.6	80	75	46-118	5.7	31
2,4-Dinitrotoluene	50	52.1	53.7	104	107	24-96	3.0	38
Pyrene	50	53.4	49.4	107	99	26-127	7.8	31
N-nitrosodi-n-propylamine	50	38.3	36.6	77	73	41-116	4.5	38
1,4-dichlorobenzene	50	35.7	31.5	71	63	36-97	12.5	28

* Test: BNA on reagent water (ug/l)

TABLE 28. LABORATORY CONTROL SAMPLE REPORT: GAS CHROMATOGRAPHY

Analyte*	Concentration Spiking	Measured LCS1	Measured LCS2	Accuracy (%) LCS1	Accuracy (%) LCS2	Accuracy (%) Limits	Precision (RPD) LCS	Precision (RPD) Limits
Arochlor 1254	5.0	4.2	3.9	84	78	20-160	7.4	20

* Test: BNA on Reagent Water (ug/l)

TABLE 29. SURROGATE CONTROL SAMPLE REPORT: GAS CHROMATOGRAPHY/ MASS SPECTROMETRY

Analyte*	Concentration Spiking	 Measured	Accuracy (%) SCS	 Limits
Phenol-D5	200	122	61	10-94
2-Fluorophenol	200	118	59	21-100
2,4,6-Tribromophenol	200	163	82	10-123
Nitrobenzene-D5	100	70.4	70	35-114
2-Fluorobiphenyl	100	70.9	71	43-116
Terphenyl-D14	100	85.5	86	33-141

* Test: BNA on reagent water (ug/l)

Precision for LCS is measured by Relative Percent Difference (RPD).

$$RPD = \frac{\text{Measured Concentration LCS1 - Measured Concentration LSC2}}{\text{(Measured Concentration LCS1 + Measured Concentration LCS2)/2}}$$

All samples analyzed concurrently by the same test are assigned the same QC lot number. Projects that contain numerous samples analyzed over several days may have multiple QC lot numbers associated with each test. The QC information illustrated in Tables 27, 28, and 29 shows the LCS and SCS recoveries from the QC lots associated with the samples, and control limits for these lots.

The samples taken during the twenty-four hour test period were received at RMAL in March 1987 under EPA Case #6955, and were logged in under two separate projects according to matrix type. The soil samples were assigned numbers JB662, JB669, JB677, JB680, and JB681. The water samples were assigned numbers JB661, JB663, JB664, JB665, JB666, JB667, JB668, JB670, JB671, JB672, JB673, JB674, JB675, JB679, JB682, JB685, JB686, JB687, and JB688.

The soil samples were analyzed as medium level soils. Samples JB662 and JB667 were also analyzed at low levels for the pesticide analysis, to achieve low detection limits. Since these samples were contaminated with organic compounds, the detection limits were lowered only by 30% in the low level analysis. Samples JB662 and JB667 were analyzed for volatile organics. Both samples foamed in the purge and trap unit during the analysis, and both contained Hazardous Substances List (HSL) aromatic hydrocarbons and acetone. Sample JB662 contained two chlorinated hydrocarbons below reporting detection limits. The samples contained three classes of tentatively identified (TIC) volatile compounds: aromatic hydrocarbons; amines; and saturated hydrocarbons. No HSL pesticides were found in either sample. Samples JB669, JB680, and JB681 were analyzed for semivolatile organic compounds only. The samples all contained HSL polyaromatic hydrocarbons below reportable detection limits. Samples JB669 and JB680 were contaminated with HSL phenolic compounds and sample JB669 contained a carboxylic acid. All three samples were heavily contaminated with saturated hydrocarbons in the semivolatile fraction. Other TICs found in the sample set were aromatic hydrocarbons and non-HSL polyaromatic hydrocarbons.

The water samples were analyzed for a single fraction. The samples which were analyzed for volatile organics mostly contained three common compounds: acetone ranging from 2300 to 7000 ug/l; 2-butanone ranging from 520 to 1500 ug/l; and triethylamine (N,N-Diethylethaneamine) ranging from 300 to 2200 ug/l. A saturated hydrocarbon was identified above reportable detection limits in three of the five samples.

The samples analyzed for semivolatiles contained three HSL compounds: Benzoic acid ranging from 500 to 4600 ug/l; 4-methylphenol ranging from 340 to 730 ug/l; and phenol ranging from 380 to 1900 ug/l. An examination of the chromatogram for all of the samples between 5 and 15 minutes showed several very large carboxylic acid interference peaks. All the target compounds within this area experienced retention time shifts, however, only benzoic acid in sample JB665 had a relative retention time shift of greater than 0.06. Benzoic acid was also found in all other samples analyzed in this sample set. Three classes of tentatively identified compounds were found in the semivolatile fractions: carboxylic acids; amines; and saturated hydrocarbons. The carboxylic acids were the most concentrated organic contaminant found throughout the sample set, ranging as high as 79000 ug/l in sample JB665. No HSL pesticides were found.

All surrogate compound recoveries for the volatile fractions of both sample sets were within quality control limits. In the pesticide fraction, several samples had the surrogate diluted out, and three others had interfering peaks in the chromatograms, which prevented the calculation of the dibutyl chlorendate (DBC) recovery. In the semivolatile fraction, several samples had the surrogate tribromophenol above its statistical QC limits. Sixteen spike compound recoveries in the volatile and semivolatile fractions were outside QC limits in the matrix spike (MS) and matrix spike duplicate (MSD) samples. Many of the recoveries and corresponding relative percent differences were outside QC limits, due to the complexity of the contamination within each sample.

Supporting data for the results given above are available in the six volumes developed by Enseco, Inc. Rocky Mountain Analytical Laboratory, entitled "B.E.S.T. Clean Up, Performance Test Results". Supporting testing and system operating data exist also in the logbook records, computer control system archival files of operations during the test period, and chain of custody records of the samples taken and retained by Resources Conservation Co.

BIBLIOGRAPHY

Burrell, J., S. Hitchcock, M. Norman, and M.J. Lampkin. The B.E.S.T.^{tm} Sludge Treatment Process: An Innovative Alternative Used at a Superfund Site. In: Treatment and Disposal, 1986.

Austin, D.A. The B.E.S.T.^{tm} Process Deoiling/Dewatering of Sludge and Soils. Hazmacon '88; Hazmat '87, Atlantic City, 1987.

Tose, M.K. Removal of Polychlorinated Biphenyls (PCBs) from Sludges and Sediments with B.E.S.T.^{tm} Extraction Technology. 1987 Annual Meeting AICHE.

NEWSPAPER ARTICLES

A New Sludge-Treatment Process. Chemical Engineering, July 21, 1986 p. 17

Company Hopes to Clean Up On PCBs. Journal-American, December 29, 1987

EPA Rates Local PCB Method No. 1. Journal of Commerce, December 30, 1987

PCB Contamination Process Rates No. 1. Hazardous Waste Management, January - February 1988

Spend Toxic-Waste Dollars on Cleanup, Not Studies. Puget Sound Business Journal, February 29, 1988

Best Could Clean Up. Daily Journal of Commerce, March 9, 1988

Process Removes PCBs From Sludge. US Water News, May 1988

PATENTS

3,925,201 dated December 9, 1975; Method of Dewatering Material Containing Solid Matter and Bound and Unbound Water, R. K. Ames

4,002,562 dated January 11, 1977; Oil Emulsion Processing, R. K. Ames

3,889,419 dated August 12, 1975; Method for Chemical Fractionation, Defatting and Dewatering of Solids and Suspensions, C. F. Emanual

4,056,466 dated November 1, 1977; Method of Dewatering Material Containing Solid Matter and Bound and Unbound Water, H. H. Peters

APPENDIX A
SAMPLING AND ANALYSIS PLAN

Preceding page blank

SAMPLING AND ANALYSIS PLAN
for
Performance Evaluation Testing

B.E.S.T. Sludge Processing System
General Refining Co. Site
Garden City, Georgia

1.0 BACKGROUND

Resources Conservation Co. has developed and tested a prototype solvent extraction based processing system for use in treating a variety of oily waste sludges. Such sludges may be used oil re-refining wastes, such as have been encountered at the General Refining Co. site, or petroleum refining sludges, such as RCRA listed wastes K-048 to K-052. The system's overall process approach is to physically separate the incoming sludge into its components of oil, water, and solids. This separation of the phases makes further treatment or disposal easier. The hazardous characteristics of sludges can potentially be isolated in a specific phase fraction, allowing each fraction to be treated more efficiently.

2.0 OBJECTIVE

A broad evaluation of the performance of the B.E.S.T. process concept, including environmental emissions, is desired. This evaluation should be representative of the performance of the system while processing the material from the General Refining Superfund site. All important process parameters shall be identified and recorded. Composition of sludge feed into the unit, and composition of processed oil, water and solids will be determined by analysis of randomly taken samples. The data should permit a comprehensive evaluation of the system performance during the test period.

Due to the short test preparation period and the limited manpower, the test will focus on the chemical composition of various streams, and not on the mechanical or electrical parameters that may determine the through-put and economic parameters. No attempt will be made to determine the chemical composition of the various sample streams as a function of through-put.

3.0 TEST PERIOD

The test period shall be from 14:00 hours on Thursday, 26 February, 1987 to 14:00 hours on Friday 27 February, 1987.

System Description

The General Refining Site is the location of a former oil recycling operation. Used motor oil was reprocessed at the facility for resale. Waste sludges were dumped in four sludge ponds at the site. There are also earlier lagoons which are presently backfilled with filter cake from a filter press apparatus used in the process.

RCC, under subcontract to Haztech, Inc., is processing the sludges under a SUPERFUND Removal Action. The sludges exhibit a number of unusual physical properties which will be defined by physical testing of the raw sludge materials.

The sludge is removed from ponds by use of pneumatic sludge pumps. The sludge is then screened in a SWECO Screen "trash rack" to remove debris larger than 1/4". Screened sludge is stored in a large surge tank, capacity approximately 50,000 gallons. The tank was part of the existing site inventory. It has been modified to allow cleaning of larger particle size debris which tends to settle to the bottom of the tank during processing.

Sludge is removed from the surge tank and sent to the B.E.S.T. sludge processing unit skids via a moyno type sludge pump. The raw sludge sampling point (discussed later) is at the outlet of the moyno pump.

The central apparatus of the B.E.S.T. sludge processing system consists of 6 skids of process equipment. The apparatus primarily consists of a method to mix the TEA with the sludge at low temperature, a centrifuge for particulates removal, an apparatus to raise the temperature of the mixture thereby achieving phase separation via decantation, and means to recover solvent from the water and oil streams. Products are dry solids, oil, and water. Presently, the water is taken to an additional water treatment system, and the oil to an oil polishing system. Primary additives to the central apparatus are the solvent, Triethylamine, antifoam, and diesel fuel. Triethylamine is the solvent used in the extraction process. Antifoam is used to control foaming in the water TEA stripping column. Diesel is used to decrease viscosity of the oil fraction. Viscosity reduction allows the oil to flow freely down the stripping column trays. Attachment (X) shows why this is necessary on this particular site. As can be seen, the viscosity of the oil is a function of water content. At a water content of about 65 %, the viscosity is so high that it prevents the oil from flowing down the trays, greatly decreasing the TEA stripping efficiency of the apparatus. Lowering the viscosity enables the stripping column to remove TEA from the oil fraction more efficiently.

4.0 SAMPLING PROCEDURE

Sample locations are identified below. Specific valve locations shall be noted and the locations recorded by photo. Photo of the TEA recycle point Pump T-324 (solvent recycle pump) done on 2/27.

In order to take samples as representative as possible, it was decided in conjunction with EPA Region 10 representatives that sample stations should be sampled at random intervals over a 24 hr. operation period. The exact number of tests to be analyzed at each sample station is outlined in section 8.0. Because of limitations in physically taking the samples, the random times generated for sample gathering were rounded to the nearest 15 min. interval. Section (****) shows a schematic representation of the 24 hr. sampling matrix used for sampling on-site.

Sample locations for this sampling are as follows;
(refer to liquid separation flow schematic of the unit)

Feed Sludge

It was very difficult to decide where to get a representative feed sample. The only location where a feed sample could be obtained downstream of the sludge feed pump (P-405) was at a "T" in the line about 4 feet from the pump. Because of the variance in consistency in the feed sludge and the variability in the amount of entrained water contained in the sludge, obtaining representative samples of the feed was thought to be the most questionable of all the sample stations. The reason for this is that the sample has to negotiate a right angle turn to reach the sample port. Because of the viscosity and density differences between the sludge and the entrained water, confidence in obtaining a completely representative sample from this location could not be achieved. As a consequence, additional samples were taken at this location to help determine sample variability.

Product Solids

It was desired to take all samples where actual process streams were flowing. Unfortunately, this was not possible for this station due to the equipment used to convey the solids from the dryer to the product solids bin. This conveyor does not operate continuously, but only on demand from a sensor located within the dryer (see C-1038 on flow diagram). Becaue of the intermittent nature of the solids discharge from the unit, it was agreed that obtaining the sample from the top of the product solids bin where the solids drop onto the collected solids pile would be the best alternative. This would ensure that the solids collected would be representative of the most current solids produced by the unit.

Product Oil

The oil product was sampled from the outlet of the oil polisher. The oil polisher is a device for the purpose of lowering the residual water content of the oil prior to discharge from the unit to a holding tank. The sample was collected from the oil polisher product line downstream of the Moyno pump.

Raw Product Water

The raw product water (prior to water treatment) was taken at a point where it enters the water treatment plant by the trim caustic pH probe. This is at a point before any water treatment plant holding tanks and represents water just as it is produced from the main B.E.S.T. unit.

Treated Product Water

It was desired to take this sample just after the two stage water treatment system. This sample was taken at the point where the treated water overflows from the turbidimeter sampling point, just prior to the pump which pumps the treated water to a holding tank.

Process Air Emissions

There are two main gas vents on the B.E.S.T. unit. One is from the nitrogen purge system. The other vent is connected to the vent condenser. Due to the fact that RCC does not currently have the expertise to reliably sample and measure these gas streams, an independent company will have to be employed to carry out this phase in the testing.

5.0 Sample Containers

Sample containers were obtained from the EPA sample bottle repository in California. Sample bottles were from QA/QC controlled lots and were received at the site with custody seals intact. Sample bottles were secured in lockers at the site. Cases were opened only as and when necessary to support sampling operations. Container types utilized are as follows:

	H20	Oil	Sludge	Solids
Metals	1 litre poly	2- 40 ml VOA	1- 32 oz. gl.	1-32.oz gl.
VOA's	2 40 ml VOA's	2- 40 ml VOA	2- 40 ml VOA	2- 40 ml VOA
PCB's	1- 32 oz. gl.	1- 40 ml VOA	1- 32 oz. gl.	1- 32 oz. gl.
BNA's	1 - 32 oz. gl	2- 40 ml VOA	1- 32 oz. gl.	1- 32 oz. gl.
TEA	1 - 40 ml VOA	1- 40 ml VOA	---	1- 32 oz. gl.

6.0 ANALYTICAL METHODS

Evaluation of test samples shall be by the following test methods:

1. Test T-1

   Total Metals: EPA-SW-846-3000 Series

   Include the following metals:

   Al
   As
   Ba
   Cr
   Cu
   Fe
   Hg
   Mn
   Ni
   Pb
   Se
   Zn

2. Test T-2

   VOA's
   (Volatile Organic
   Analysis) EPA Method 624 Purge & Trap GC/MS

3. Test T-3

   PCB's: EPA Method 608 GC/ECD

4. Test T-4

BNA's
(Base-Neutral-Acid Extractables) EPA Method 625 GC/MS

5. Test T-5

Triethylamine Packed Column GC/FID

6. Test T-6

Oil & Grease EPA Method 413.1 Partition Gravimetric
(for water fraction)

7. Test T-7

TCLP
(Toxicity Characteristic Leaching Procedure) November 7, 1986
Federal Register Appendix

Do metal spectrum as shown above for the Total Metals.

8. Test T-8

Oil & Grease Standard Methods for the Examination of Water and Wastewater, 15th Edition, 1980 Method 503 D. (for solids fraction)

9. Test T-9

Physical Data TBD

As appropriate

pH
temp
viscosity
particle size
process physical separation performance monitoring

10. Test T-10

BTX in gas stream
(Benzene, Toluene Xylene) Carbon Bed - Purge/Trap GC/MS

11. Test T-11

Mercury in gas stream; EPA Method as used by Entropy

7.0 SAMPLE STATION IDENTIFICATION

Key sample stations have been identified as follows:

- A. Sludge Feed to unit
- B. Water out of B.E.S.T. Skid
- C. Solids out of B.E.S.T. Skid
- D. Oil out of B.E.S.T. Skids (after polisher)
- E. Treated Product Water
- F. Water Treatment Plant Sludge
- G. Air Emissions

8.0 SAMPLE GATHERING PROCEDURE/PLAN

Samples were gathered from the locations identified in __ above as follows:

Station	A	B	C	D	E	F	G
Metals	16r	8r	8r	8r	con.	8r	end
VOA	NO	2r	2r	2r	con	2r	2r
PCB's	8r	2r	2r	2r	NO	2r	2r
BNA's	4r	2r	2r	2r	NO	2r	2r
TEA	NO	2r	2r	2r	NO	2r	2r

Sample time are at the frequency indicated at random times. The random numbers for sample frequency were generated on a portable calculator, Model HP-11C, S/N 2442A13899. The random number is generated as a part of a uniformly distributed pseudo-random number sequence based on "seed" used to initiate the sequence. The calculator manufacturer's instruction book indicates that the program passes the spectral test (D. Knuth, Seminumerical Algorithms, Vol.2, 1969.)

The Random Number generation procedure resulted in sample times as follows:

For Location A: Raw Sludge Feed

2:16
3:33
3:39
3:49
4:31
4:34
6:16
10:36
15:45
17:27
19:11
19:50
20:40

For Location B:

1:17
3:56
7:27
8:59
9:31
9:58
19:22
20:50

For Location C:

1:11
1:13
10:00
18:24
18:43
20:20
21:26
22:04

For Location D:

4:43
10:58
13:14
14:47
16:30
19:21
21:30
23:29

For Location E:

1:51
7:33
13:51
18:36

Field Duplicates:

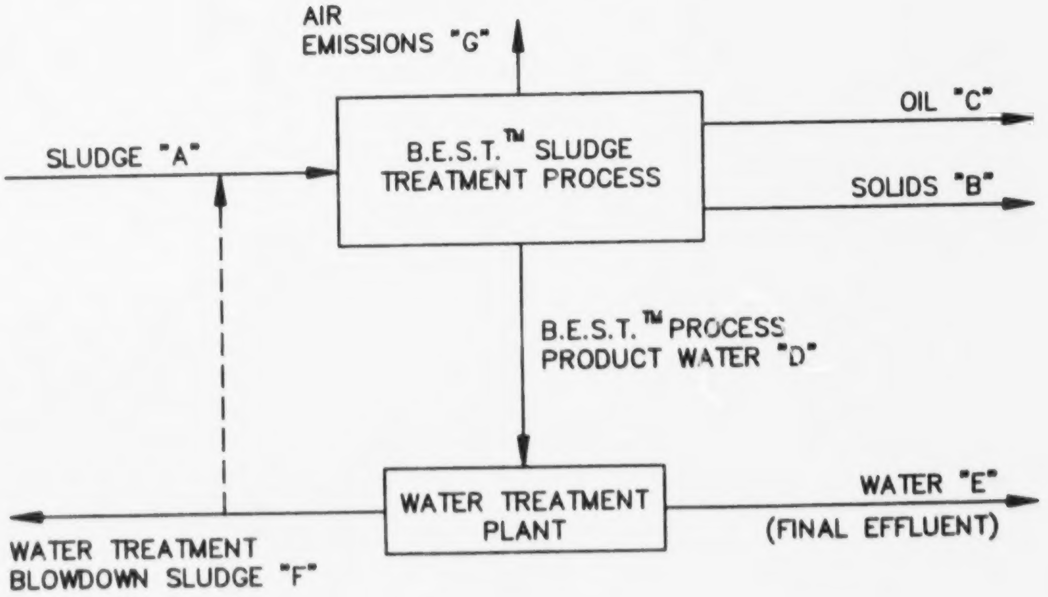
Field Duplicates equal to 10 % of field samples will be gathered.

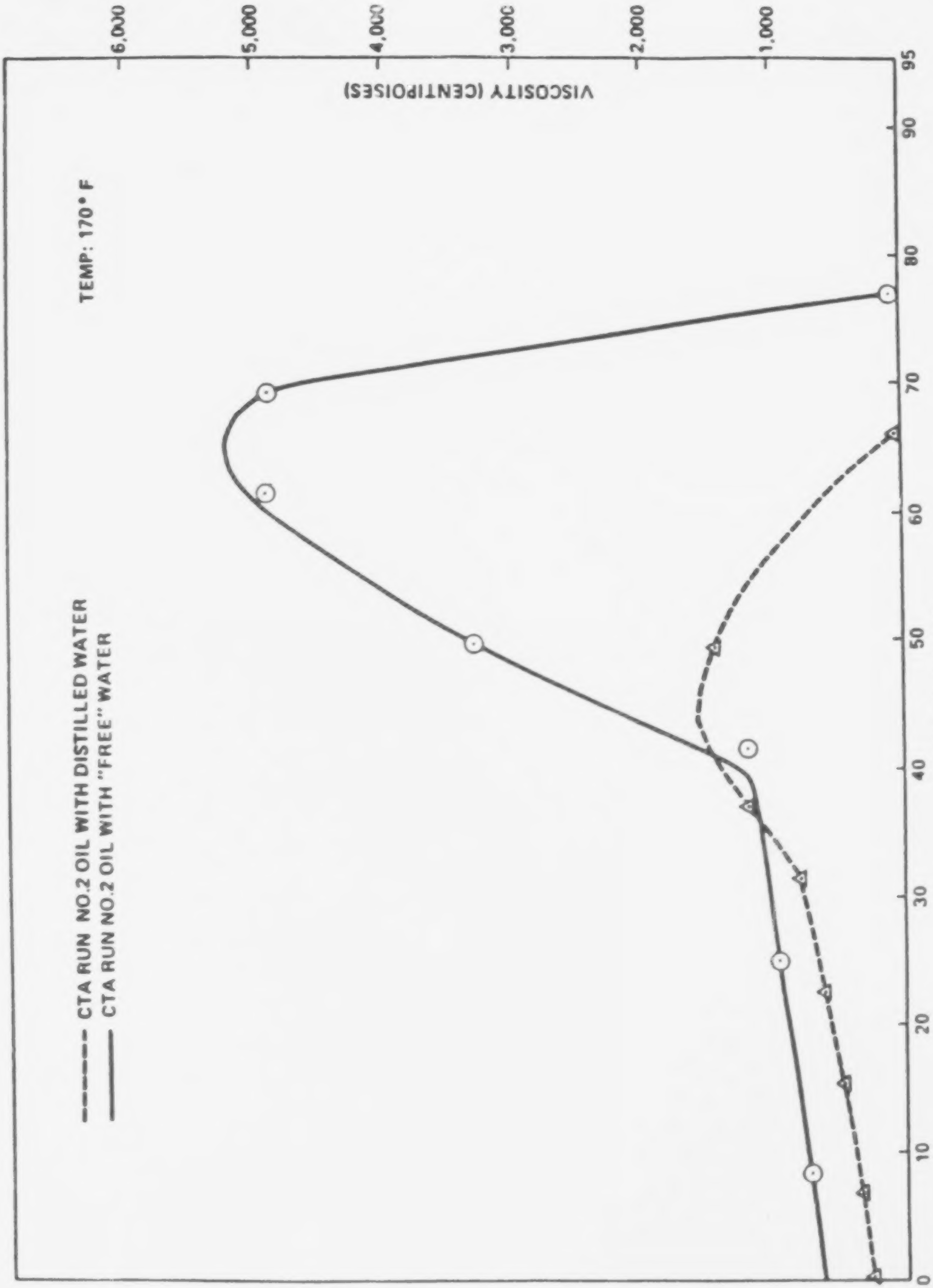
Field Blanks:

Distilled water Field Blanks in 32 oz. glass containers were placed in ice chests included with the sample shipment to the laboratory.

B.E.S.T.™ SLUDGE TREATMENT PERFORMANCE SUMMARY
GENERAL REFINING SITE
20 FEBRUARY – 27 FEBRUARY, 1987

SAMPLE IDENTIFICATION


AIR
EMISSIONS "G"
SLUDGE "A"
B.E.S.T.™ SLUDGE
TREATMENT PROCESS
OIL "C"
SOLIDS "B"
B.E.S.T.™ PROCESS
PRODUCT WATER "D"
WATER TREATMENT
PLANT
WATER "E"
(FINAL EFFLUENT)
WATER TREATMENT
BLOWDOWN SLUDGE "F"



- - - - - CTA RUN NO.2 OIL WITH DISTILLED WATER
——— CTA RUN NO.2 OIL WITH "FREE" WATER
TEMP: 170° F
VISCOSITY (CENTIPOISES)
6,000
5,000
4,000
3,000
2,000
1,000
(% WATER IN OIL)
0
10
20
30
40
50
60
70
80
90
95

APPENDIX B
DATA SUMMARY

Preceding page blank

DATA SUMMARY

FEBRUARY 26-27, 1987

B.E.S.T.^{TM} SLUDGE TREATMENT PROCESS

AT THE

GENERAL REFINING CO. SITE
GARDEN CITY, GEORGIA

UNDER SUBCONTRCT
TO THE
U.S. ENVIRONMENTAL PROTECTION AGENCY
THROUGH
ERCS CONTRACT 68-01-6859

SUPERFUND REMOVAL ACTION

RESOURCES CONSERVATION CO.
3101 N.E. NORTHUP WAY
BELLEVUE, WA 98004
(206) 828-2400

APRIL 18, 1988

REVISION: 3

TABLE OF CONTENTS

		PAGE
SECTION 1	Process Overview	1
SECTION 2	Raw Sludge Feed	3
SECTION 3	Raw Product Water	9
SECTION 4	Product Solids	14
SECTION 5	Product Oil	20
SECTION 6	Treated Product Water	25
SECTION 7	Air	30
SECTION 8	Process Performance	32
SECTION 9	Key Operating Data	44
SECTION 10	Comparison with RCRA Listed Wastes .... from the Petroleum Refinery Industry	50
SECTION 11	Analytes Not Detected in Raw Sludge	56
SECTION 12	Analytes Not Detected in Product Solids	64
SECTION 13	Analytes Not Detected in Raw Product Water	72
SECTION 14	Analytes Not Detected in Treated Product Water .	77
SECTION 15	Analytes Not Detected in Product Oil	82
SECTION 16	Sample Key	87

LIST OF TABLES

PAGE

Table 1 Raw Sludge Feed 4
Sample Location Identification "A"
Table 2 Metals Concentration in Raw Sludge 5
General Refining Site
Table 3 Raw Sludge Feed (mg/kg) 6
SemiVolatiles
Table 4 TCLP Extract in Raw Sludge 7
General Refining Site
Table 5 Raw Sludge Feed 8
Chlorinated Dioxins and Furans EPA Method 8280
Table 6 Raw Water Product 10
Sample Location Identification "B"
Table 7 Raw Product Water (mg/L) 11
Metals
Table 8 Raw Water (mg/L) 12
Volatiles
Table 9 Raw Product Water (mg/L) 13
SemiVolatiles
Table 10 Product Solids 15
Sample Location Identification "C"
Table 11 Total Metals in Product Solids 16
General Refining Site
Table 12 TCLP Extract of Product Solids 17
General Refining Site
Table 13 Volatile Organic Constituents in Product Solids . 18
General Refining Site
Table 14 Total Semi-Volatile Organic Constituents in
Product Solids 19
General Refining Site
Table 15 Product Oil 21
Sample Location Identification "D"
Table 16 Metals Concentration in Product Oil 22
General Refining Site
Table 17 Volatiles Concentration in Product Oil 23
General Refining Site
Table 18 Semi Volatiles Concentration in Product Oil 24
General Refining Site
Table 19 Treated Water Product 26
Sample Location Identification "E"
Table 20 Treated Product Water (mg/L) 27
Metals
Table 21 Treated Product Water (ug/L) 28
Volatiles
Table 22 Treated Product Water (mg/L) 29
SemiVolatiles
Table 23 Summary of Emissions 31

Table 24 B.E.S.T.^{TM} Unit Separation Performance 33
Full Scale Processing Performance
General Refining Site Materials
Table 25 Comparison of Laboratory B.E.S.T.^{TM} Simulation .. 34
to Full Scale Processing Performance on
General Refining Site Materials
Table 26 O & G (mg/L) 35
Table 27 Product Fractions TEA (ppm) 36
Table 28 B.E.S.T.^{TM} Performance Summary 37
General Refining Site
Lead In Input/Output Streams
Table 29 B.E.S.T.^{TM} Performance Summary 38
General Refining Site
PCBs In Input/Output Streams
Table 29A Raw Sludge 39
Table 29B Product Solids 40
Table 29C Product Oil 41
Table 29D Raw Product Water 42
Table 29E Water Treatment Blowdown 43
Table 30 Laboratory Data on Slop Oil Emulsion, DAF Float,
and API Bottoms 51
Compared with General Refining Site Sludge
Table 31 Oil & Grease in Product Solids 52
Table 32 Lead Concentration in Product Oil 53
Comparison Between Listed Sludges and
General Refining Sludge
Table 33 Chromium Concentration in Product Oil 54
Comparison Between Listed Sludges and
General Refining Sludge
Table 34 EP Toxicity of Waste Extract 55
B.E.S.T.^{TM} Treated Solids Comparison between
Listed Sludges and General Refining Site
Table 35 Raw Sludge Metals 57
Table 36 Raw Sludge SemiVolatile Organics 58
Table 37 Raw Sludge HSL Volatile Organics TCLP 60
Aqueous Leachate EPA Method 624
Table 38 Raw Sludge HSL SemiVolatile Organics TCLP 61
Aqueous Leachate
Table 39 Raw Sludge PCBs TCLP Aqueous Leachate 63
EPA Method 608
Table 40 Product Solids Volatile Compounds 65
EPA Method 608
Table 41 Product Solids SemiVolatile Compounds 66
EPA Method 608
Table 42 Product Solids HSL Volatile Organics TCLP 68
Aqueous Leachate EPA Method 624
Table 43 Product Solids HSL SemiVolatile Organics 69
TCLP Aqueous Leachate
Table 44 Product Solids Pesticides/PCB's 71
EPA Method 608
Table 45 Raw Product Water Volatile Compounds 73
EPA Method 608
Table 46 Raw Product Water SemiVolatile Compounds 74

EPA Method 608
Table 47 Raw Product Water PCBs Pesticides EPA 76
Method 608
Table 48 Treated Product Water Volatile Compounds 78
EPA Method 608
Table 49 Treated Product Water SemiVolatile Compounds 79
EPA Method 608
Table 50 Treated Product Water Pesticides/PCB's 81
EPA Method 608
Table 51 Product Oil HSL Volatile Organics TCLP 83
Aqueous Leachate EPA Method 624
Table 52 Product Oil HSL SemiVolatile Organics TCLP 84
Aqueous Leachate
Table 53 Product Oil PCBs TCLP Aqueous Leachate 86
EPA Method 608
Table 54 Sample Key for B.E.S.T.^{TM} Sludge 88
Processing BDAT Test

LIST OF FIGURES

PAGE

Figure 1 B.E.S.T.^{TM} Sludge Treatment Performance Summary 2
General Refining Site
26 February - 27 February 1987
Figure 2 F1-201 Mixed Sludge Feed #1B/Hr 45
Figure 3 Plant Operating Rate - Ton/Day 46
Figure 4 TEA/Feed Ratio 47
Figure 5 F1-F514 Steam to Water Stripper - 1B/Hr.......... 48
Figure 6 P1-305 Dryer Operating Pressure - H_2O 49

SECTION 1

PROCESS OVERVIEW

B.E.S.T.™ SLUDGE TREATMENT PERFORMANCE SUMMARY
GENERAL REFINING SITE
26 FEBRUARY – 27 FEBRUARY, 1987

SAMPLE IDENTIFICATION

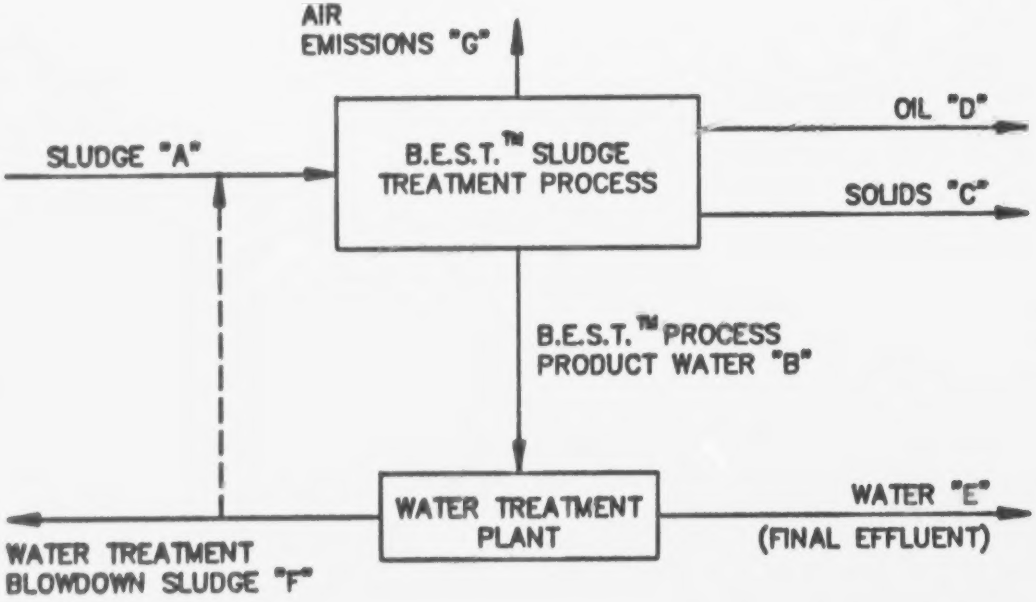

AIR
EMISSIONS "G"
SLUDGE "A"
B.E.S.T.™ SLUDGE
TREATMENT PROCESS
OIL "D"
SOLIDS "C"
B.E.S.T.™ PROCESS
PRODUCT WATER "B"
WATER TREATMENT
PLANT
WATER "E"
(FINAL EFFLUENT)
WATER TREATMENT
BLOWDOWN SLUDGE "F"

FIGURE 1

SECTION 2

RAW SLUDGE FEED

TABLE 1

Raw Sludge Feed

Sample Location Identification "A"

Time	Metals	PCB's	TCLP	Appendix IX	VOA	BNA
16:15	(X)	(X)				-
17:30	(X)(X)dup	(X) A				-
17:45	(X)	A				(X) X dup
18:00	(X)	A				-
18:30	(X)	A				-
18:45	(X)	(X)				(X)
20:15	(X) X dup	(X) X dup				-
00:30	(X)	A				(X)
05:45	(X)*		A	A*		-
07:30	(X)	(X)				-
09:15(9:25)	(X)	A				-
09:45	(X)	A	A			-
10:45(11:00	(X)	(X)				-
11:00(dup)	(X)	A				-
12:45	(X)	(X)				-
13:00	(X)	(X)				(X)

Discrepancies

1) Additional PCB analysis added at the request of J. Barich

2) TCLP & Appendix IX added at the request of D. Pepson of EPA Land Disposal Restrictions Program

3) Sample (Tag # 1038) for field dup at 2/26 20:15 was not analyzed (shipment confirmed)

4) Field dup for BNA on 2/26 17:45 got entered into RMAL as one sample; as a consequence was not analyzed.

X = To Be Tested
(X)= Completed
A = Added Later

TABLE 2
METALS CONCENTRATION IN RAW SLUDGE
GENERAL REFINING SITE
(mg/kg)

RMAL/EPA Sample No.

Metals	005	006	072	007	008	011	012	013	024	039
Al	460.	340.	380.	380.	420.	330.	390.	420.	420.	470.
As	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<.6	<.6	<.6	<.6
Ba	210.	190.	250.	260.	320.	160.	270.	370.	310.	220.
Cr	6.2	5.	6.	6.	7.	5.	7.	7.	7.	5.
Cu	23.	23.	24.	24.	24.	21.	25.	30.	27.	21.
Fe	680.	670.	750.	740.	770.	660.	740.	770.	750.	720.
Pb	2,700.	2,700.	4,000.	3,100.	3,600.	2,200.	3,400.	4,300.	3,700.	2,800.
Mn	5.5	4.2	5.4	4.9	5.3	4.5	5.2	5.0	4.9	4.7
Hg	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
Ni	<4.	<4.	<4.	<4.	<4.	<4.	<4.	<4.	<4.	<4.
Se	<4.	<2.	<4.	<4.	<4.	<4.	<4.	<2.	<4.	<2.
Zn	310.	280.	300.	300.	320.	270.	310.	330.	310.	280.

	043	053	050	051	064	065	030	x	σ	n
Al	430.	350.	380.	370.	380.	360.	420.	394.	40.0	17.
As	<.6	<.6	<.6	<.6	<.6	<.6	<10.	<.6	–	–
Ba	360.	180.	200.	180.	200.	160.	230.	239.	66.6	17.
Cr	7.	5.	7.	6.	7.	6.	6.	6.2	.81	17.
Cu	27.	24.	29.	26.	24.	24.	23.	23.5	5.4	17.
Fe	770.	670.	750.	710.	700.	670.	710.	719.	39.	17.
Pb	4,100.	3,200.	3,300.	3,200.	2,900.	2,700.	2,900.	3,223.	571.	17.
Mn	5.4	4.4	5.	4.9	4.5	4.4	4.4	4.86	0.4	17.
Hg	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05		17.
Ni	<4.	<4.	<8.	<4.	<4.	<4.	<4.	<4.		17.
Se	<4.	<2.	<4.	<4.	<4.	<4.	<4.	<4.		17.
Zn	350.	300.	330.	320.	310.	300.	280.	306.	21.	17.

TABLE 3

RAW SLUDGE FEED
(mg/kg)

	RMAL/EPA Sample #					
	007	012	024	065	$\bar{X}$	O
SemiVolatiles						
Bis-(2-ethylhexyl)phthalate	<3.	<4.	<7.	49.	24.	35.
Chrysene	4.7	4.5	<7.	5.6	3.7	2.5
Fluorene	3.4	<4.	<7.	4.2	1.9	2.2
2-Methylnaphthalene	37.	36.	47.	50.	42.5	7.047
Naphthalene	22.	22.	28.	30.	25.5	4.123
N-nitrosidiphenylamine	5.6	4.8	7.5	8.3	6.55	1.626
Phenanthrene	13.	13.	16.	17.	14.75	2.06
Phenol	4.5	<4.	<7.	<3.	5.1	2.6
1,2-dichlorobenzene	<3.	<3.	<3.	3.3	.82	1.6
Fluoranthene	<3.	<3.	<3.	3.7	.92	1.8
Pyrene	<3.	<3.	<3.	3.6	.9	1.8

TABLE 4

TCLP EXTRACT IN RAW SLUDGE
GENERAL REFINING SITE

(mg/L)

Constituent	RMAL/EPA Sample No. 030	RMAL/EPA Sample No. 053
Al	11.	6.1
As	<0.02	<0.006
Ba	0.62	0.13
Cr	0.09	0.07
Cu	<0.02	<0.02
Fe	36.	19.
Pb	5.1	4.2
Mn	0.30	0.16
Hg	<0.001	<0.001
Ni	<0.08	<0.08
Se	<0.008	<0.008
Zn	16.	11.
PCB's	<.04	<.04
Acetone	<.12	0.27
Benzene	0.03	0.040
2-butanone	<.12	0.13
Ethylbenzene	0.029	0.043
4-methyl-2-pentanone	0.054	0.062
Toluene	0.14	0.19
1, 1, 1-Trichlorethane	0.027	0.044
Trichloroethene	<.025	0.037
Xylenes	0.14	0.19
M-Xylenes	0.066	0.086
O+P Xylenes	0.072	0.10
Bis(2-ethylhexyl)phthalate	0.13	<.01
Napthalene	0.023	0.027
2-Methylnapthalene	<.01	0.011
2,4-dimethylphenol	0.081	0.11
4-methylphenol	0.21	0.26
Phenol	0.11	0.12
2-methylphenol	<.01	0.010

TABLE 5

RAW SLUDGE FEED

CHLORINATED DIOXINS AND FURANS
EPA METHOD 8280

Parameter	Results	Units	Reporting Limit
Tetrachlorodibenzo-p-dioxins	N.D.	ng/g	0.55
Pentachlorodibenzo-p-dioxins	N.D.	ng/g	1.5
Hexachlorodibenzo-p-dioxins	N.D.	ng/g	0.72
Heptachlorodibenzo-p-dioxins	N.D.	ng/g	1.0
Octachlorodibenzo-p-dioxins	N.D.	ng/g	7.1
Tetrachlorodibenzofurans	N.D.	ng/g	0.32
Pentachlorodibenzofurans	N.D.	ng/g	1.1
Hexachlorodibenzofurans	N.D.	ng/g	1.7
Heptacholoribenzofurans	N.D.	ng/g	1.0
Octachlorodibenzofurans	N.D.	ng/g	0.32

Sampled: 02/27/87
Analyzed: 05/05/87

N.D. = Not detected

RCC - SAMPLE NO. 1076
LAB ID NO. 63109-030

SECTION 3

RAW PRODUCT WATER

B.15

TABLE 6

Raw Water Product

Sample Location Identification "B"

Time	Metals	Pest/ PCB's	TCLP	Appendix IX	VOA	BNA	TEA	O&G
15:15	(X)	(X)						-
18:00	(X)				(X)(X dup)			(X)
21:30	(X)					(X)		-
23:00	(X)						(X)	-
23:30	(X)	(X)						-
24:00(00:15)	(X)						(X)	-
09:15(09:20)	(X)(X dup)				(X)			(X) X dup
10:45	(X)	(X) X dup		A				-

Discrepancies:

1) BNA not analysed for 2/27 10:15

2) 2/27 10:15 Field duplicate was broken in transit

3) O & G Field dup was not analysed

X = To Be Tested
(X)= Completed
A = Added Later

B.16

TABLE 7

RAW PRODUCT WATER
(mg/L)

RMAL/EPA Sample #

Metals	MJC201	MJC204	MJC205	MJC206	MJC208	MJC023	MJC221	MJC222	MJC225	$\bar{x}$	σ	n
Al	43.6	65.7	71.0	64.3	51.0	23.	54.5	75.3	91.4	60.0	19.8	9
Sb	<.12	<.12	<.12	<.12	<.12	N/A	<.12	<.12	<.12	–	–	–
As	<.1	<.1	<.1	<.1	<.1	.04	<.1	<.1	<.1	–	–	–
Ba	.21	.67	.56	.57	.557	1.0	1.18	1.60	1.19	.837	.433	9
Be	<.005	<.005	<.005	<.005	<.005	N/A	<.005	<.005	<.005	–	–	–
Cd	.028	.028	.052	.038	.045	N/A	.058	.080	.063	.049	.018	8
Ca	80.	69.1	49.5	41.3	36.2	N/A	31.6	38.0	30.6	47.	18.2	8
Cr	.028	.062	.079	.087	.083	.09	.114	.155	.123	.091	.036	9
Co	<.025	<.025	<.025	<.025	<.025	N/A	<.025	<.025	<.025	–	–	–
Cu	.116	.212	.174	.172	.341	.35	.294	.325	.149	.237	.091	9
Fe	1.68	4.93	6.47	7.94	5.95	7.3	14.1	19.9	16.3	9.40	5.98	9
Pb	33.2	57.5	80.4	86.0	73.0	56.0	158.	230.	206.	109.	71.	9
Mg	.398	.816	.816	1.06	.875	N/A	3.20	3.8	2.55	1.70	1.28	8
Mn	.026	.042	.040	.054	.047	.06	.111	.149	.106	.071	.041	9
Hg	.0003	.0003	.0003	.0007	.0007	<.0001	<.002	<.002	.0008	.0003	.0003	9
Ni	.069	.101	.124	.120	.112	<.08	.145	.193	.189	.117	.059	9
K	18.7	20.4	19.9	17.9	18.7	N/A	13.4	16.6	18.	17.9	2.2	8
Se	<.05	<.05	<.05	<.05	<.05	<.08	<.050	<.05	<.05	–	–	–
Ag	<.02	<.02	<.02	<.02	<.02	N/A	<.020	<.02	<.02	–	–	–
Na	2,800.	2,910.	3,080.	2,730.	2,880.	N/A	2,490.	2,890.	3,320.	2,512.	902.	8
Tl	.019	.022	.018	<.01	.016	N/A	.018	.015	.018	.016	.007	8
Sn	<.1	<.1	<.1	<.1	<.1	N/A	<.1	.101	<.1	–	–	–
V	<.015	<.015	<.015	<.015	<.015	N/A	.025	.028	.034	–	–	–
Zn	2.35	4.49	6.43	7.21	6.71	4.4	11.5	14.5	12.6	7.8	4.1	–

B-17

TABLE 8

RAW WATER VOLATILES
(mg/L)

RMAL/EPA Sample #

	JB663	JB664	JB675
Volatiles			
Chloromethane	<1.0	0.11	<2.5
Methylene Chloride	0.12	0.12	<1.3
Acetone	5.70	7.00	6.10
2-butanone	1.30	1.50	<2.5
Triethylamine (Estimated from GC/MS output)	2.20	0.30	0.87
Total Xylenes	<0.5	0.098	0.93

TABLE 9

RAW PRODUCT WATER
(mg/L)

RMAL/EPA Sample #

	JB665	JB673	JB674	x	σ
SemiVolatile					
Bis(2-ethylhexyl)phthalate	<.13	<.2	<.13		
Chrysene	<.13	<.2	<.13		
Fluorene	<.13	<.2	<.13		
2-Methylnaphthalene	<.13	<.2	<.13		
Naphthalene	<.13	<.2	<.13		
N-nitrosidiphenylamine	<.13	<.2	<.13		
Phenanthrene	<.13	<.2	<.13		
Phenol	.38	1.9	1.6	1.29	
1,2-dichlorobenzene	<.13	<.2	<.13		
Fluoranthene	<.13	<.2	<.13		
Pyrene	<.13	<.2	<.13		
4-methylphenol	.34	.73	.63	.57	
Benzoic Acid	4.6	1.2	1.2	2.3	
4-chloro-3-methylphenol	<.13	<.2	<.13		
Butylbenzylphthalate	<.13	<.2	<.13		
2,4-dimethylphenol	<.13	.05	.053	.03	

SECTION 4

PRODUCT SOLIDS

TABLE 10

Product Solids

Sample Location Identification "C"

Time	Metals	PCB's	TCLP	Appendix IX	VOA	BNA	TEA	O&G	Phys
15:15	(X)	A	(X)					X	-
15:30	(X)	(X)	(X)		(X)			(X)	-
24:00	(X)(X)		(X)(X dup)			(X)		(X) A dup	-
08:15	(X)2-A dups		(X) A dup				(X)	(X)(X dup)	-
08:45	(X)		(X)					(X)	-
10:00	(X)	(X)	X		(X) X dup			X	-
11:30	(X)		(X)			(X) X dup		X	-
12:00	(X)		(X)			A	(X)(X dup)	(X)	-

X = To Be Tested
(X)= Completed
A = Added Later

TABLE 11

TOTAL METALS IN PRODUCT SOLIDS
GENERAL REFINING SITE
(mg/kg)

PRODUCT SOLIDS

TOTAL METALS

RMAL/EPA Sample No.

	MJC202	MJC203	MJC212	MJC213	MJC218	070	MJC219	MJC220	MJC224	MJC226	MJC368	$\bar{x}$	σ	n
Metals														
Al	2,490.	2,530.	2,380.	2,450.	2,870.	2,300.	3,100.	2,450.	3,000.	3,200.	3,210.	2,725.	352.	11
Sb	<13.	<13.	<13.	<13.	<12.	N/A	<25.	<12.	<12.	<12.	<12.	-	-	-
As	<5.2	<5.2	<5.3	<5.3	<5.2	<.2	<5.2	<5.2	<5.1	<5.1	<5.1	-	-	
Ba	554	585.	516.	549.	105.	140.	321.	190.	578.	416.	583.	412.	190.	11
Be	<.52	<.52	<.53	<.53	<.52	N/A	<1.	2.4	<.51	<.5	<.51	-	-	-
Cd	4.1	<2.6	3.8	3.5	4.5	N/A	<5.2	7.6	3.	3.	4.7	3.4	2.2	10
Ca	13,900.	13,100.	14,400.	13,100.	11,900.	N/A	14,200.	12,600.	12,300.	16,200.	16,600.	13,830.	1,578.	10
Cr	19.	19.	19.	18.	20.	18.	21.	22.	23.	24.	26.	20.8	2.6	11
Co	<2.6	<2.6	<2.7	<2.6	<2.6	N/A	<5.2	4.3	4.2	<2.5	<2.5	-	-	-
Cu	103.	101.	112.	105.	115.	100.	134.	114.	112.	136.	137.	115.	14.	11
Fe	4,970.	4,900.	4,460.	4,650.	5,220.	4,000.	5,290.	4,500.	4,760.	5,200.	5,710.	4,451.	1,382.	11
Pb	18,800.	18.800.	21,300.	20,000.	24,700.	21,300.	15,100.	23,200.	31,100.	27,300.	29,300.	22,809.	4,886.	11
Mg	515.	533.	506.	526.	552.	N/A	608.	755.	571.	643.	679.	589.	82.	10
Mn	26.	27.	25.	25.	26.	23.	26.	24.	23.	27.	29.	23.7	6.1	11
Hg	<.1	<.1	<0.1	<.1	<.1	.007	N/A	<.1	<.1	<.1	<.1	<.1	-	-
Ni	10.	8.4	8.6	7.9	9.1	<8.	10.	9.5	3.8	8.6	10.	7.8	3.1	11
K	218.	271.	241.	261.	301.	N/A	228.	480.	334.	293.	387.	301.	81.	10
Se	<2.6	<2.6	<2.7	<2.6	<2.6	<8.	<2.6	<2.6	<2.6	<2.5	<2.5	-	-	-
Ag	<2.1	<2.1	<2.1	<2.1	<2.1	N/A	<4.2	2.9	<2.	<2.	<2.	-	-	-
Na	75,100.	74,800.	93,300.	84,600.	87,000.	N/A	10,300.	88,000.	81,700.	87,900.	87,600.	77,030.	24,183.	10
Tl	<5.2	<5.2	<5.3	<5.3	<5.2	N/A	<5.2	<5.2	<5.1	<5.1	<5.1	-	-	-
Sn	11.	16.	<11.	<11.	<10.	N/A	<21.	<10.	10.	30.	<10.	16.75	9.22	10
V	6.9	6.2	5.8	6.3	5.5	N/A	4.4	7.7	7.1	7.6	7.4	6.5	1.05	10
Zn	909.	862.	902.	839.	1,030.	930.	1,210.	972.	1,040.	1,240.	1,260.	,018.	154.	11

TABLE 12

TCLP EXTRACT OF PRODUCT SOLIDS
GENERAL REFINING SITE
(mg/L)

RMAL/EPA Sample No.

Constituent	003	004	021	022	040	070	041	052	059	062	x	σ
Al	1.1	1.0	1.3	1.5	1.9	N/A	1.7	2.4	1.6	2.1	1.62	.46
As	<.03	<.03	<.06	<.06	<.06	N/A	<.06	<.06	<.06	<.02		
Ba	<.03	<.03	<.05	<.05	<.05	N/A	<.05	<.05	<.05	<.05		
Cr	<.05	<.05	<.1	<.1	<.1	N/A	<.1	<.1	<.1	<.1		
Cu	<.03	<.03	<.06	<.06	<.06	N/A	<.06	<.06	<.06	<.06		
Fe	1.8	1.6	2.8	3.0	4.7	N/A	4.1	5.3	5.0	7.1	3.93	1.796
Pb	5.9	5.2	11.	4.2	4.0	N/A	4.0	4.9	N/A	12.	6.4	3.2
Mn	.44	.43	.45	.44	.52	N/A	.49	.49	.54	.61	.49	.059
Hg	<.001	<.001	<.001	<.001	<.001	N/A	<.001	<.001	<.001	<.002		
Ni	<.2	<.2	<.4	<.4	<.4	N/A	<.4	<.4	<.4	<.4		
Se	<.04	.008	<.008	<.04	<.04	N/A	<.04	<.04	<.04	<.08	.0009	.003
Zn	22.	21.	22.	22.	25.	N/A	25.	26.	30.	33.	25.1	4.08
Ethylbenzene	.52	N/A	.054	.096	.12	.14	.059	.042	<.025	ND	.11	.16
Toluene	.17	N/A	.18	.35	.42	.56	.22	.16	.090	.11	.251	.158
T-Xylenes(B	.28	N/A	.31	.51	.71	.72	.31	.21	.17	.097	.369	.227
M-Xylene	.13	N/A	.14	.24	.30	N/A	.15	.099	.073	.045	.147	.085
O,P-Xylenes	.15	N/A	.16	.27	.41	N/A	.16	.11	.093	.052	.176	.114
2,4-dimethylphenol	.019	N/A	.013	.018	.013	.0086	.013	.011	.011	<.01	.11	.007
4-methylphenol	.037	N/A	.053	.071	.060	.029	.057	.045	.050	.044	.0495	.0125
Phenol	.035	N/A	.040	.056	.020	<.01	.033	.013	.018	.017	.026	.027
4-methyl-2-pentanone	<.05	N/A	.052	.059	<.05	<.10	<.05	<.05	<.05	<.05	.11	.023
Benzene	<.025	N/A	<.025	<.025	<.025	<.05	<.025	<.025	<.025	<.025		
Trichloroethene	<.025	N/A	<.025	<.025	.030	.030	<0.25	<.025	<.025	<.025	.006	.013

TABLE 13

VOLATILE ORGANIC CONSTITUENTS IN PRODUCT SOLIDS
GENERAL REFINING SITE
(mg/kg)

	RMAL/EPA Sample No.	
	JB662	JB677
Constituents		
Methylene Chloride	0.97	1.0
Acetone	2.5	3.8
Trichloroethene	0.32	<2.4
Benzene	0.28	.49
Tetrachloroethene	0.70	<2.4
Toluene	9.	9.2
Ethylbenzene	5.	6.4
Total Xylenes	35.	35.
Triethylamine	81.	10.
(Estimated by GC/MS)		

TABLE 14

TOTAL SEMI-VOLATILE ORGANIC CONSTITUENTS
IN PRODUCT SOLIDS
GENERAL REFINING SITE
(mg/kg)

	RMAL/EPA Sample No.		
	JB669	JB680	JB681
Constituents			
Bis-(2-ethylhexyl)phthalate	6.6	5.2	5.5
Chrysene	<19.	<17.	<20.
Fluorene	<19.	<17.	20.
2-Methylnaphthalene	2.4	<17.	<20.
Naphthalene	2.3	<17.	<20.
N-nitrosidiphenylamine	<19.	<17.	<20.
Phenanthrene	2.5	2.1	2.3
Phenol	<19.	<17.	<20.
1,2-dichlorobenzene	<19.	<17.	<20.
Fluoranthene	<19.	<17.	<20.
Pyrene	<19.	<17.	<20.
4-methylphenol	3.8	3.1	<20.
Benzoic Acid	10.	<82.	<97.
4-chloro 3-methylphenol	<19.	1.9	<20.
Butylbenzylphthalate	<19.	2.8	<20.

SECTION 5

PRODUCT OIL

TABLE 15

Product Oil

Sample Location Identification "D"

Time	Metals	PCB's	TCLP	Appendix IX	VOA	BNA	TEA	O&G	Phys
14:00	(X)	(X)			(X)	(X)	(X)		X -
18:45	(X)	(X)							X -
01:00	(X)					(X)			-
03:15	(X)						(X) X dup		-
05:15	(X)						(X)		-
06:30	(X)(X dup)				(X)(X dup)				-
09:15	(X)	(X)(X dup)							-
11:30	(X)				(X)	(X)(X dup)			X -
14:00	(X)	(X)			(X)	(X)	(X)		-

Discrepancies:

1) One TEA Field dup not analyzed

2) Both Sample & Field dup for BNA's on 2/27 11:30 were not analyzed

3) Physical Characteristics were analyzed on different samples

X = To Be Tested
(X)= Completed
A = Added Later

TABLE 16

METALS CONCENTRATION IN PRODUCT OIL

GENERAL REFINING SITE

(mg/kg)

RMAL/EPA Sample No.

	001	010	026	032	035	036	038	045	048	058	067	x	σ (n=11)
Metals													
Al	700.	390.	420.	870.	560.	1,000.	710.	810.	790.	720.	680.	695.	183.
As	<.6	<.6	<.6	1.0	1.6	0.8	1.0	0.8	0.8	0.8	0.6	.67	.5
Ba	550.	390.	280.	740.	310.	910.	350.	730.	660.	350.	310.	507.	220.
Cr	14.	11.	10.	19.	12.	21.	15.	17.	17.	15.	14.	15.	3.35
Cu	50.	22.	28.	55.	47.	72.	56.	59.	59.	54.	54.	50.5	14.2
Fe	1,800.	1,000.	1,100.	1,900.	1,500.	2,100.	1,800.	1,800.	1,800.	1,700.	1,700.	1,655.	333.
Pb	6,000.	4,300.	4,000.	7,900.	5,900.	10,200.	6,000.	8,300.	8,300.	6,500.	5,800.	6.654.	1,852.
Mn	15.	7.5	7.8	15.	11.	17.	13.	13.	12.	12.	12.	12.3	2.9
Hg	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05		
Ni	<4.	<4.	<4.	<4.	<4.	<4.	<4.	<4.	<4.	<4.	<4.		
Se	<10.	<4.	<10.	<10.	<8.	<10.	<10.	<10.	<10.	<10.	<10.		
Zn	660.	420.	460.	800.	580.	940.	750.	770.	730.	690.	680.	680.	150.

TABLE 17

VOLATILES CONCENTRATION IN PRODUCT OIL
GENERAL REFINING SITE
(mg/kg)

RMAL/EPA Sample No.

	001	036	038(Dup.)	058	049	$\bar{x}$	σ
Volatiles							
Ethylbenzene	12.	32.	95.	14.	28.	36.	34.
Toluene	5.0	<12.	82.	<11.	14.	20.	35.
Xylenes	99.	290.	570.	110.	150.	267.	190.

B-29

TABLE 18

SEMI VOLATILES CONCENTRATION IN PRODUCT OIL
GENERAL REFINING SITE
(mg/kg)

	RMAL/EPA Sample No.						
	001	026	068	074	049	$\bar{x}$	σ
Constituents							
Acenaphthene	92.	60.	66.	81.	64.	72.6	13.4
Anthracene	61.	29.	44.	54.	43.	46.	12.
Chrysene	<20.	<20.	20.	25.	<20.	9.	12.
Dibenzofuran	62.	39.	<18.	55.	43.	40.	24.
Fluorene	180.	120.	120.	150.	120.	138.	26.83
2-methylnaphthalene	1,700.	1,200.	1,200.	1,500.	1,300.	1,380.	216.79
Naphthalene	330.	320.	290.	370.	310.	324.	29.66
N-nitrosidiphenylamine	150.	110.	110.	130.	110.	122.	17.89
Phenanthrene	360.	250.	250.	330.	260.	290.	51.48
Pyrene	30.	27.	23.	43.	26.	29.8	7.79
4-methylphenol	85.	<20.	<18.	<20.	<20.	17.	38.
Phenol	46.	40.	50.	63.	51.	55.8	16.17
Bis(2-ethylhexyl)phthalate	<20.	<20.	<18.	180.	<20.	45.	90.

SECTION 6

TREATED PRODUCT WATER

TABLE 19

Treated Water Product

Sample Location Identification "E"

Time	Metals	PCB's	TCLP	Appendix IX	VOA	BNA	TEA	O&G
23:15	(X)	(X)					(X)	-
23:30	(X)							(X) X dup
23:45(24:00)	(X)(X dup)				(X)			-
03:45	(X)	(X)(X dup)		A A dup				-
04:45	(X)				(X)			-
05:00	(X)					(X)(X dup)	X X dup	-
09:30	(X)							(X)
12:00	(X)					(X)		-

Discrepancies:

1) TEA not run on 2/27 05:00 sample (unknown reason)

X = To Be Tested
(X)= Completed
A = Added Later

B-32

TABLE 20

TREATED PRODUCT WATER
(mg/L)

RMAL/EPA Sample #

	MJC207	MJC209	MJC210	MJC211	MJC215	MJC214	MJC216	MJC217	MJC223	MJC367	x̄	σ	n=10
Metals													
Al	37.6	37.5	38.6	38.1	35.6	35.8	35.8	38.6	33.2	36.3	36.3	2.16	
Sb	<.048	<.048	<.048	<.048	<.048	<.048	<.048	<.048	<.096	<.096	-	-	
As	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	-	-	
Ba	.106		.112	.104	.108	.086	.082	.097	.084	.091	.105	.098	.011
Be	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.004	<.004	-	-	
Cd	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.02	<.02	-	-	
Ca	639.	656.	686.	695.	743.	713.	748.	756.	782.	805.	722.	54.	
Cr	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.02	<.02	-	-	
Co	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.02	<.02	-	-	
Cu	<.008	<.008	<.012	<.008	<.008	<.008	<.008	.015	<.016	<.016	-	-	
Fe	<.052	<.052	<.052	<.052	<.052	<.052	<.052	.132	.170	.264	-	-	
Pb	.152	.158	.143	.150	.121	.095	.095	.125	.082	.429	.155	.10	
Mg	.724	.771	.795	.867	1.22	1.18	1.42	1.41	2.11	2.11	1.26	.52	
Mn	<.008	<.008	<.008	<.008	<.008	<.008	<.008	.01	.022	<.016	-	-	
Hg	<.0002	<.0002	<.0002	<.0002	<.0002	<.0002	<.0002	.0002	<.0002	<.0002	-	-	
Ni	.022	.021	.019	.028	.028	.026	.025	.026	<.02	.03	.0225	.0086	
K	9.71	9.15	9.35	9.69	9.93	9.73	9.89	11.6	13.3	17.7	11.0	2.67	
Se	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	-	-	
Ag	<.008	<.008	<.008	<.008	<.008	<.008	<.008	<.008	<.016	<.016	-	-	
Na	1,710.	1,680.	1,740.	1,740.	1,760.	1,760.	1,760.	1,980.	2,210.	2,620.	1,896.	30	
Tl	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	-	-	
Sn	<.04	<.04	<.04	<.04	<.04	<.04	<.04	<.04	<.08	<.08	-	-	
V	<.006	<.006	<.006	<.006	<.006	<.006	<.006	<.006	<.012	<.012	-	-	
Zn	.072	.070	.087	.077	.095	.097	.107	.135	.183	.272	.120	.064	

TABLE 21

TREATED PRODUCT WATER
(mg/L)

RMAL/EPA Sample #

	JB668	JB672
Volatiles		
Methylene Chloride	.085	<.25
Acetone	2.3	2.3
2-Butanone	.58	.52
Triethylamine (Estimated by GC/MS)	.42	.30

TABLE 22

TREATED PRODUCT WATER
(mg/L)

RMAL/EPA Sample #

	JB673	JB682
SEMIVOLATILES		
BIS(2-ETHYLHEXYL)PHTHALATE	<.2	<.13
CHRYSENE	<.2	<.13
FLUORENE	<.2	<.13
2-METHYLNAPHTHALENE	<.2	<.13
NAPHTHALENE	<.2	<.13
N-NITROSIDIPHENYLAMINE	<.2	<.13
PHENANTHRENE	<.2	<.13
PHENOL	1.9	1.2
1,2-DICHLOROBENZENE	<.2	<.13
FLUORANTHENE	<.2	<.13
PYRENE	<.2	<.13
4-METHYLPHENOL	.73	.45
BENZOIC ACID	1.2	.50
4-CHLORO-3-METHYLPHENOL	<.2	<.13
BUTYLBENZYLPHTHALATE	<.2	<.13
2,4-DIMETHYLPHENOL	<.05	<.13

SECTION 7

AIR

TABLE 23

SUMMARY OF AIR EMISSIONS

	RUN 1	2	3	4	x
Condenser Exhaust					
Concentration, ppmvd					
Benzene	321	321	339	311	323
Mercury	<0.00496	<0.00496	<0.00496	<0.00496	<0.00496
Toluene	164	144	145	132	146
Triethylamine	22,560	13,235	29,928	29,003	23,682
Xylene	200	182	191	161	184
Emission Rate, Lb/Hr					
Benzene	0.00127	0.00127	0.000926	0.00108	0.00114
Mercury	<0.000000052	<0.000000041	<0.000000042	<0.000000037	<0.000000043
Toluene	0.000769	0.000676	0.000469	0.000540	0.000614
Triethylamine	0.0985	0.0492	0.131	0.0103	0.0954
Xylene	0.00108	0.000983	0.000710	0.000763	0.000884
Oil Polisher Outlet					
Concentration, ppmvd					
Benzene	39.3				
Mercury	<0.0677				
Toluene	1,502				
Triethylamine	20,130				
Xylene	8,271				
Emissions Rate, Lb/ Hr					
Benzene	0.00473				
Mercury	<0.00000210				
Toluene	0.0214				
Triethylamine	0.314				
Xylene	0.135				

SECTION 8

PROCESS PERFORMANCE

TABLE 24

B.E.S.T.^{TM} UNIT SEPARATION PERFORMANCE
FULL SCALE PROCESSING PERFORMANCE
GENERAL REFINING SITE MATERIALS

	Raw Sludge	SEPARATED PHASE FRACTIONS		
		Oil %	Water %	Solids %
OIL %	27	99.	0.0033	0.81
WATER %	66	0.88	>99.	<0.5
SOLIDS %	7	*	0.81	>98.

* Test not conducted on routine basis.

TABLE 25

COMPARISON OF LABORATORY B.E.S.T.™ SIMULATION
TO
FULL SCALE PROCESSING PERFORMANCE
ON
GENERAL REFINING SITE MATERIALS

	LAB PROCESS SIMULATION				FULL SCALE TREATMENT			
		SEPARATED PHASE FRACTION				SEPARATED PHASE FRACTION		
	RAW SLUDGE	OIL	WATER	SOLIDS	RAW SLUDGE	OIL	WATER	SOLIDS
OIL %	36	84	0.017	5.7	27	99	0.0033	0.81
WATER %	56	16*	>99	-	66	0.88	>99	<0.5
SOLIDS %	8	**	-	94	7	***	0.81	>98

* BS&W

** PARTICULATES ARE INCLUDED IN BS&W

*** NOT MEASURED

TABLE 26

O & G
(mg/L)

RMAL/EPA Sample #

	Solids	Raw H^2O	Treated H^2O
004	.80%	14.	
-017			113.
-021	1.0%		
-022	.89%		
-040	.812%		
-041	.888		
-042		52.	
-052	.583		
-054			77.
-062	.697		
-070	.776		

TABLE 27

PRODUCT FRACTIONS
TEA
(ppm)

RMAL/EPA Sample #	Oil	Raw Product Water	Treated Product Water	Solids
-001	<500.			
-015		1,800.		
-016			380.	
-018			460.	
-023		1,100		
-032	<500.			
-034			760.	
-035				<100.
-037			720.	
-046				9,700.
-049	<500.			
-060				7,700.
-062				7.400.

TABLE 28

B.E.S.T.^{TM} Performance Summary
General Refining Site

LEAD
In Input/Output Streams

2/26 - 2/27/87

	Raw Sludge A mg/kg	Solids B mg/kg	Oil C mg/kg	Product H^2O D mg/L	H^2O Effluent E mg/L	H^2O Waste F mg/L
Sample I.D.						
"n"	17.	12.	11.	9.	9.	2.
Range	2,200. - 7,400.	4,500. - 31,100. (15,000.)	4,000. - 10,200.	33.2 - 230.	0.082 - 0.429	72. - 150.
Mean	3,480.	21,280.	6,654.	108.9	0.162	111.
SD(n-1) [σ]	1,160.	7,045.	1,852.	71.	0.1	-
% of infl.	100%					

TABLE 29

B.E.S.T.™ Performance Summary
General Refining Site

PCBs
in Input/Output Streams

2/26 - 2/27/87

	Raw Sludge A mg/kg	Product H_2O B mg/L	Solids C mg/kg	Oil D mg/kg	H^2O Effluent E mg/L	H^2O TMT Waste Sludge F mg/L
Sample I.D.						
"n"	18.	6.	3.	5.	-	2.
Range	1.8 - 11.4	>.01	0 - 0.37	8.2 - 11.	-	>.01
Mean	5.94	-	-	9.28	-	-
SD(n-1) [σ]	2.65	-	-	1.1	-	-

TABLE 29A

B.E.S.T.^{TM} Performance Summary
General Refining Site

RAW SLUDGE
(TOTAL ANALYSIS)
(mg/kg)

2/26 - 2/27/87

SAMPLE #	PCB
005	8.6
006	4.6
072	7.7
007	3.5
008	6.0
011	5.7
012	3.3
013	5.0
024	5.5
030	2.2
039	1.8
043	6.9
053	11.3
071	11.4
050	7.2
051	5.8
064	4.8
065	5.6

TABLE 29B

B.E.S.T.^{TM} Performance Summary
General Refining Site

PRODUCT SOLIDS
(mg/kg)

2/26 - 2/27/87

SAMPLE #	PCB
003	.37
JB662	<1.7
JB677	<1.7

TABLE 29C

B.E.S.T.^{TM} Performance Summary
General Refining Site

PRODUCT OIL
(mg/kg)

2/26 - 2/27/87

SAMPLE #	PCB
001	8.2
010	8.7
045	9.6
073	11.0
049	8.9

TABLE 29D

B.E.S.T.™ Performance Summary
General Refining Site

RAW PRODUCT WATER
(mg/kg)

2/26 - 2/27/87

SAMPLE #	PCB
JB661	<.006
JB666	<.010
JB667	<.006
JB670	<.006
JB671	<.006
JB679	<.006

TABLE 29E

B.E.S.T.™ Performance Summary
General Refining Site

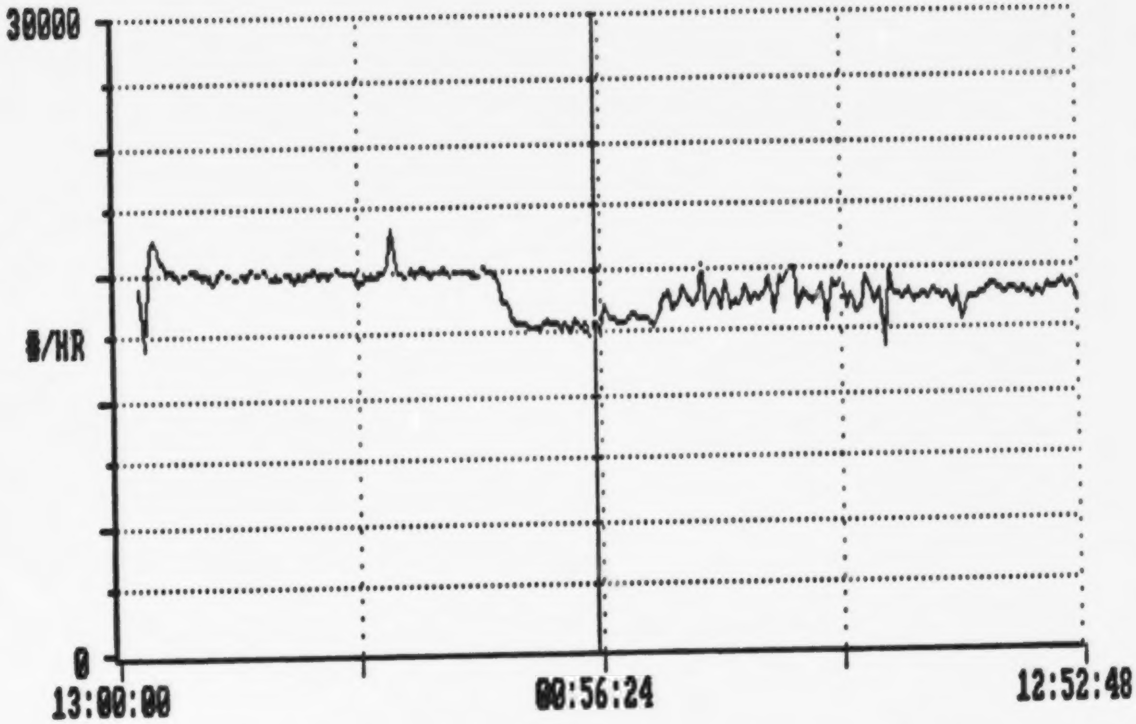
WATER TREATMENT BLOWDOWN
(mg/kg)

2/26 - 2/27/87

SAMPLE #	RESULT
057	<.010
066	<.010

SECTION 9

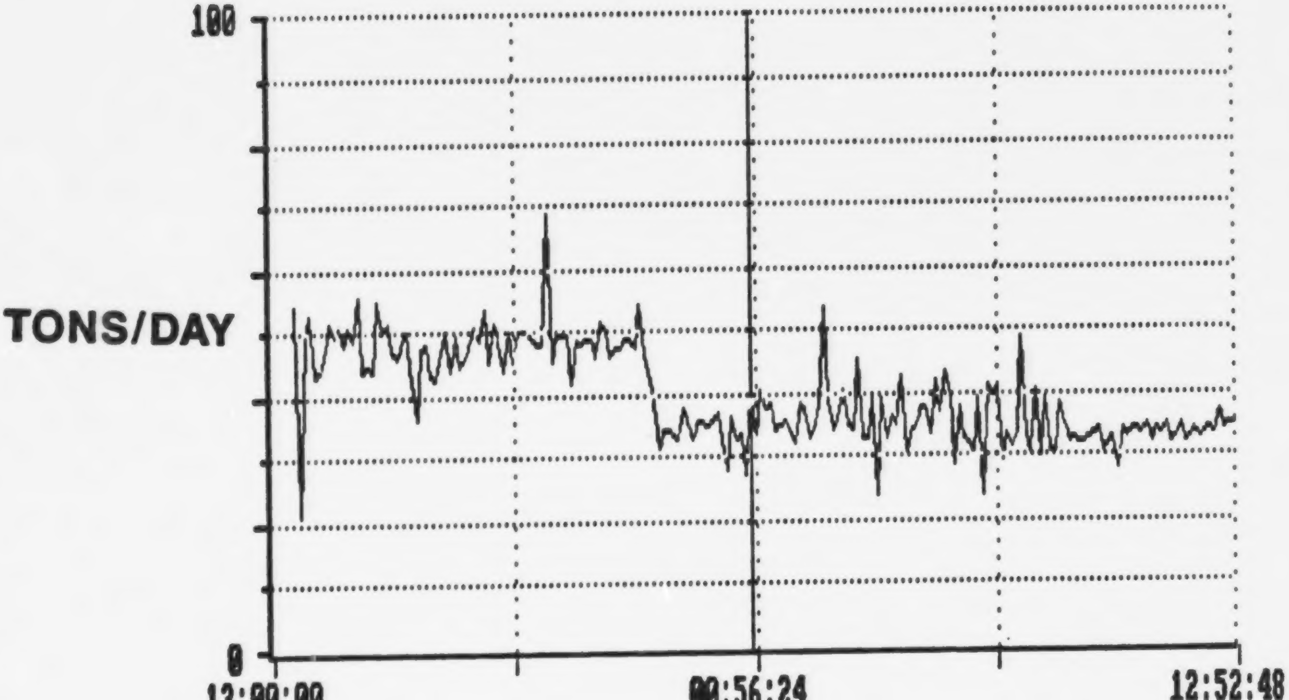
KEY OPERATING DATA



FI-201 MIXED SLUDGE FEED #1B/HR

(FROM 1300HR 2/26/87 THRU 1252HR 2/27/87)

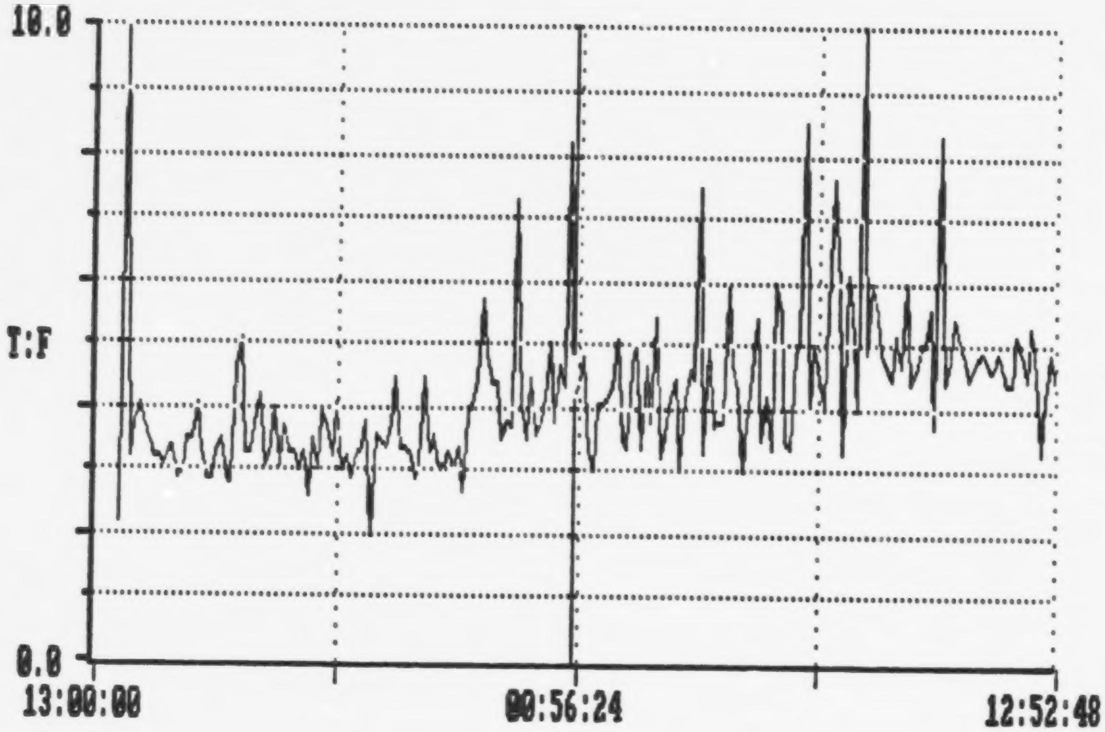
FIGURE 2



PLANT OPERATING RATE – TON/DAY

(FROM 1300HR 2/26/87 THRU 1252HR 2/27/87)

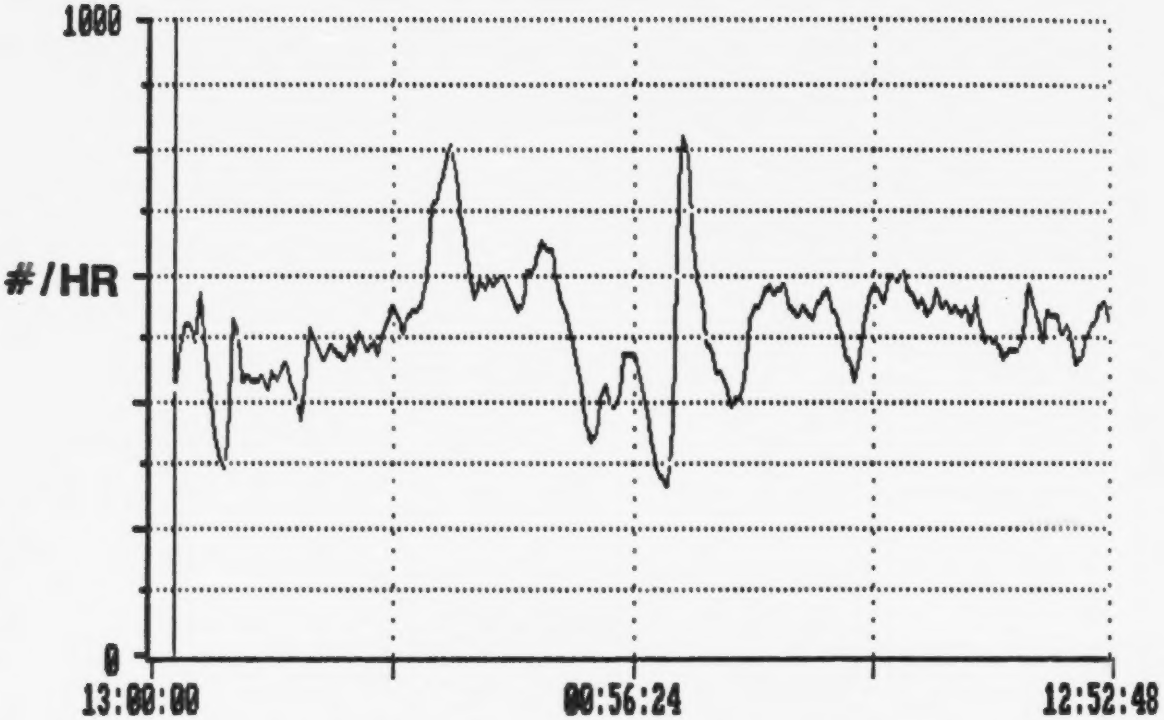
FIGURE 3



TEA/FEED RATIO

(FROM 1300HR 2/26/87 THRU 1252HR 2/27/87)

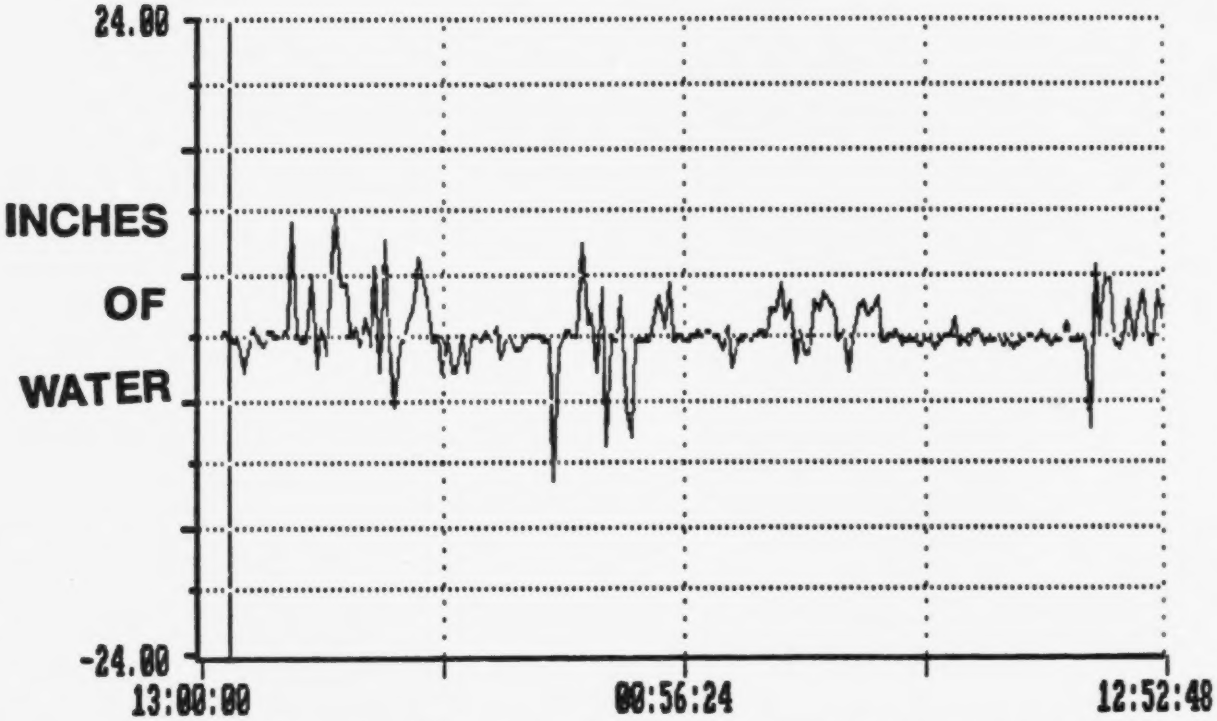
FIGURE 4



FI–514 STEAM TO WATER STRIPPER– 1B/HR

(FROM 1300HR 2/26/87 THRU 1252HR 2/27/87)

FIGURE 5



PI–305 DRYER OPERATING PRESSURE–"H_2O

(FROM 1300HR 2/26/87 THRU 1252HR 2/27/87)

FIGURE 6

SECTION 10

COMPARISON WITH RCRA LISTED WASTES FROM THE PETROLEUM REFINERY INDUSTRY

TABLE 30

LABORATORY DATA
ON
SLOP OIL EMULSION, DAF FLOAT, AND API BOTTOMS

COMPARED WITH
GENERAL REFINING SITE SLUDGE

	CLIENT "A" K049 WASTE				CLIENT "A" K048 WASTE				CLIENT "A" K051 WASTE				GENERAL REFINERY SITE			
	RAW SLUDGE	PHASE FRACTIONS			RAW SLUDGE	PHASE FRACTIONS			RAW SLUDGE	PHASE FRACTIONS			RAW SLUDGE	PHASE FRACTION		
COMPOSITION		OIL	WATER	SOLIDS		OIL	WATER	SOLIDS		OIL	WATER	SOLIDS		OIL	WATER	SOLIDS
OIL %	22	-	0.037	1.5	7.9	-	0.0097	0.2	6.5	-	0.032	0.2	36	-	0.017	5.7
WATER %	70	6.0	-	-	87	2	-	-	45	<2	-	-	56	16*	-	-
SOLIDS %	8	0.69	0.0092	-	5.	0.29	<0.001	-	49	0.6	0.044	-	8	**	-	-

* BOTTOM SEDIMENT AND WATER (BS&W)

** PARTICULATES ARE INCLUDED IN BS&W

TABLE 31

OIL & GREASE IN PRODUCT SOLIDS

BENCH SCALE SIMULATION DATA
COMPARED WITH
GENERAL REFINING SITE SLUDGE

CLIENT ID	SLUDGE WASTE ID	% OIL & GREASE
EPA	General Refining Site	5.7
A	K049	1.5
A	K048	0.2
B	BLIND REFINERY SLUDGE SAMPLE	0.2
B	BLIND REFINERY SLUDGE SAMPLE	0.9
B	BLIND REFINERY SLUDGE SAMPLE	1.2
A	K051	0.2
C	K051	3.3
D	K048	1.4
D	K051	0.4

TABLE 32

LEAD CONCENTRATION IN PRODUCT OIL

COMPARISON BETWEEN LISTED SLUDGES
AND
GENERAL REFINING SLUDGE

Pb - (mg/kg)

CLIENT ID	SLUDGE WASTE ID	RAW SLUDGE	OIL PRODUCT	% OF TOTAL Pb	SOLIDS	% OF TOTAL Pb
EPA	General Refining Site	3,223	6,654	56	22,809	43
A	K049	345	27	2.6	2,800	97.4
A	K048	55	<1	0.2	840	99.8
A	K051	310	15	0.4	540	99.6
E	K051	39	3.5	0.3	660	99.8
E	K052	27	5.3	1.7	470	97.5
D	K048	106	<5	<0.12	1,800	98.2
D	K051	1,018	4.0	.10	4,000	99.8
F	K051	4.6	<2	<0.3	290	[illegible]
F	K048	1.4	<2	<1.6	280	[illegible]
B	BLIND SAMPLE	255	2.8	0.02	390	100
B	BLIND SAMPLE	154	<2.0	<0.2	640	100
B	BLIND SAMPLE	7.8	6.1	3.3	220	79
G	K051	430	<5	<0.02	900	100
G	K051	460	<5	<0.07	2,100	100
H	K048	47	<1	<0.2	750	99

TABLE 33

CHROMIUM CONCENTRATION IN PRODUCT OIL

COMPARISON BETWEEN LISTED SLUDGES
AND
GENERAL REFINING SLUDGE
Cr - (mg/kg)

CLIENT ID	SLUDGE WASTE ID	RAW SLUDGE	OIL PRODUCT	% OF TOTAL Cr	SOLIDS	% OF TOTAL Cr
EPA	General Refining Site	6.2	15	76.4	20.8	23.6
A	K049	376	15	1.1	3,600	98.9
A	K048	175	5	0.3	3,200	99.7
A	K051	1,290	27	0.2	2,300	99.8
E	K051	260	67	0.8	4,300	99.2
E	K052	185	1.6	0.1	3,300	99.9
D	K048	628	2.7	0.43	10,800	100
D	K051	790	3.6	0.07	3,100	100
F	K051	19	2.8	2	1,600	98
F	K048	26	1.9	<0.1	6,500	<99.9
B	BLIND SAMPLE	72	0.7	0.2	110	99
B	BLIND SAMPLE	24	0.9	0.5	100	99
B	BLIND SAMPLE	1.65	1.2	3.1	57	96
G	K051	260	160	1.2	540	98.8
G	K051	400	400	6	1,700	94
G	K048	440	8.2	0.2	7,100	99.8

TABLE 34

EP TOXICITY OF WASTE EXTRACT

B.E.S.T.^{TM} TREATED SOLIDS
COMPARISON BETWEEN LISTED SLUDGES AND GENERAL REFINING SITE
(mg/kg)

CLIENT ID	SLUDGE WASTE ID	LEAD (mg/kg) TOTAL	LEAD (mg/kg) EP TOX	CHROMIUM (mg/kg) TOTAL	CHROMIUM (mg/kg) EP TOX
EPA	General Refining Site	18,000	6.4	20	<0.1
E	K051	660	0.14	4,300	1.3
E	K052	470	0.33	3,300	0.10
D	K048	1,800	<0.2	10,800	0.1
D	K051	4,000	0.22	3,100	0.02
F	K051	290	0.33	1,600	0.02
B	BLIND SAMPLE	390	<0.2	110	0.02
B	BLIND SAMPLE	640	<0.2	100	0.02
G	K051	900	.74	540	0.05
G	K051	2,100	0.7	1,700	0.12
H	K048	750	<0.2	7,100	0.04

SECTION 11

ANALYTES NOT DETECTED
IN
RAW SLUDGE

TABLE 35

RAW SLUDGE

METALS

Parameter	Results	Units	Reporting Limit
Antimony	N.D.	mg/kg	5
Beryllium	N.D.	mg/kg	0.1
Cobalt	N.D.	mg/kg	1
Osmium	N.D.	mg/kg	10
Potassium	N.D.	mg/kg	500
Silver	N.D.	mg/kg	0.5
Thallium	N.D.	mg/kg	0.8
Tin	N.D.	mg/kg	3

Sampled: 02/27/87
Analyzed: 03/22/87

N.D. = Not detected

B-65

TABLE 36

RAW SLUDGE

SEMIVOLATILE ORGANICS

Parameter	Results	Units	Reporting Limit
Acenaphthene	N.D.	mg/kg	>3.0
Acenaphthylene	N.D.	mg/kg	>3.0
Anthracene	N.D.	mg/kg	>3.0
Benzo(a)anthracene	N.D.	mg/kg	>3.0
Benzo(a)pyrene	N.D.	mg/kg	>3.0
Benzo(b)fluoranthene	N.D.	mg/kg	>3.0
Benzo(g,h,i)perylene	N.D.	mg/kg	>3.0
Benzo(k)fluoranthene	N.D.	mg/kg	>3.0
Benzyl alcohol	N.D.	mg/kg	>3.0
Bis(2-chloroethoxy)methane	N.D.	mg/kg	>3.0
Bis(2-chloroethyl)ether	N.D.	mg/kg	>3.0
Bis(2-chloroisopropyl)ether	N.D.	mg/kg	>3.0
4-Bromophenyl phenyl ether	N.D.	mg/kg	>3.0
Butylbenzyl phthalate	N.D.	mg/kg	>3.0
4-Chloroaniline	N.D.	mg/kg	>3.0
2-Chloronaphthalene	N.D.	mg/kg	>3.0
4-Chlorophenyl phenyl ether	N.D.	mg/kg	>3.0
Dibenz(a,h)anthracene	N.D.	mg/kg	>3.0
Dibenzofuran	N.D.	mg/kg	>3.0
1,3-Dichlorobenzene	N.D.	mg/kg	>3.0
1,4-Dichlorobenzene	N.D.	mg/kg	>3.0
3,3'-Dichlorobenzidine	N.D.	mg/kg	>12
Diethyl phthalate	N.D.	mg/kg	>3.0
Dimethyl phthalate	N.D.	mg/kg	>3.0
Di-n-butyl phthalate	N.D.	mg/kg	>3.0
2,4-Dinitrotoluene	N.D.	mg/kg	>3.0
2,6-Dinitrotoluene	N.D.	mg/kg	>3.0
Di-n-octyl phthalate	N.D.	mg/kg	>3.0
Hexachlorobenzene	N.D.	mg/kg	>3.0
Hexachlorobutadiene	N.D.	mg/kg	>2.0
Hexachlorocyclopentadiene	N.D.	mg/kg	>3.0
Hexachloroethane	N.D.	mg/kg	>3.0
Indeno(1,2,3-cd)pyrene	N.D.	mg/kg	>3.0
Isophorone	N.D.	mg/kg	>3.0
2-Nitroaniline	N.D.	mg/kg	>3.0
3-Nitroaniline	N.D.	mg/kg	>3.0
4-Nitroaniline	N.D.	mg/kg	>3.0
Nitrobenzene	N.D.	mg/kg	>3.0
N-Nitrosodi-n-propylamine	N.D.	mg/kg	>3.0
1,2,4-Trichlorobenzene	N.D.	mg/kg	>3.0
Benzoic acid	N.D.	mg/kg	>15.0
2-Chlorophenol	N.D.	mg/kg	>3.0

TABLE 36 (CONT'D)

RAW SLUDGE

SEMIVOLATILE ORGANICS

Parameter	Results	Units	Reporting Limit
2,4-Dichlorophenol	N.D.	mg/kg	>3.0
2,4-Dimethylphenol	N.D.	mg/kg	>3.0
4,6-Dinitro-2-methylphenol	N.D.	mg/kg	>15.0
2,4-Dinitrophenol	N.D.	mg/kg	>15.0
2-Methylphenol	N.D.	mg/kg	>3.0
4-Methylphenol	N.D.	mg/kg	>3.0
2-Nitrophenol	N.D.	mg/kg	>3.0
4-Nitrophenol	N.D.	mg/kg	>15.0
4-Chloro-3-methylphenol	N.D.	mg/kg	>3.0
Penthachlorophenol	N.D.	mg/kg	>3.0
2,4,5-Trichlorophenol	N.D.	mg/kg	>3.0
2,4,6-Trichlorophenol	N.D.	mg/kg	>3.0

Sampled: 02/26/87
Analyzed: 04/16/87

N.D. = Not detected

TABLE 37

RAW SLUDGE

HSL VOLATILE ORGANICS
TCLP AQUEOUS LEACHATE
EPA METHOD 624

Parameter	Results	Units	Reporting Limit
Bromoform	N.D.	mg/L	0.025
Bromomethane	N.D.	mg/L	0.05
Carbon disulfide	N.D.	mg/L	0.025
Carbon tetrachloride	N.D.	mg/L	0.025
Chlorobenzene	N.D.	mg/L	0.025
Chlorodibromoethane	N.D.	mg/L	0.025
Chloroethane	N.D.	mg/L	0.05
2-Chloroethylvinyl ether	N.D.	mg/L	0.05
Chloroform	N.D.	mg/L	0.025
Chloromethane	N.D.	mg/L	0.05
Dichlorobromomethane	N.D.	mg/L	0.025
1,1-Dichloroethane	N.D.	mg/L	0.025
1,2-Dichloroethane	N.D.	mg/L	0.025
1,1-Dichloroethylene	N.D.	mg/L	0.025
1,2-Dichloropropane	N.D.	mg/L	0.025
cis-1,3-Dichloropropene	N.D.	mg/L	0.025
trans-1,3-Dichloropropene	N.D.	mg/L	0.025
2-Hexanone	N.D.	mg/L	0.05
Methlylene chloride	N.D.	mg/L	0.05
Styrene	N.D.	mg/L	0.025
1,1,2,2-Tetrachloroethane	N.D.	mg/L	0.025
Tetrachloroethene	N.D.	mg/L	0.025
1,2-trans-Dichloroethylene	N.D.	mg/L	0.025
1,1,2-Trichloroethane	N.D.	mg/L	0.025
Trichloroethene	N.D.	mg/L	0.025
Vinyl Acetate	N.D.	mg/L	0.05
Vinyl chloride	N.D.	mg/L	0.05
1-4-Dioxane	N.D.	mg/L	0.5
1-2-Dibromoethane	N.D.	mg/L	0.025

Sampled: 02/27/87
Analyzed: 04/07/87

N.D. = Not detected

TABLE 38

RAW SLUDGE

HSL SEMIVOLATILE ORGANICS
TCLP AQUEOUS LEACHATE

Parameter	Results	Units	Reporting Limit
Acenaphthene	N.D.	mg/L	0.01
Acenaphthylene	N.D.	mg/L	0.01
Anthracene	N.D.	mg/L	0.01
Benzo(a)anthracene	N.D.	mg/L	0.01
Benzo(a)pyrene	N.D.	mg/L	0.01
Benzo(b)fluoranthene	N.D.	mg/L	0.01
Benzo(g,h,i)perylene	N.D.	mg/L	0.01
Benzo(k)fluoranthene	N.D.	mg/L	0.01
Benzyl alcohol	N.D.	mg/L	0.01
Bis(2-chloroethoxy)methane	N.D.	mg/L	0.01
Bis(2-chloroethyl)ether	N.D.	mg/L	0.01
Bis(2-chloroisopropyl)ether	N.D.	mg/L	0.01
4-Bromophenyl phenyl ether	N.D.	mg/L	0.01
Butylbenzyl phthalate	N.D.	mg/L	0.01
4-Chloroaniline	N.D.	mg/L	0.01
2-Chloronaphthalene	N.D.	mg/L	0.01
4-Chlorophenyl phenyl ether	N.D.	mg/L	0.01
Chrysene	N.D.	mg/L	0.01
Dibenz(a,h)anthracene	N.D.	mg/L	0.01
Dibenzofuran	N.D.	mg/L	0.01
1,2-Dichlorobenzene	N.D.	mg/L	0.01
1,3-Dichlorobenzene	N.D.	mg/L	0.01
1,4-Dichlorobenzene	N.D.	mg/L	0.01
3,3'-Dichlorobensidine	N.D.	mg/L	0.04
Diethyl phthalate	N.D.	mg/L	0.01
Dimethyl phthalate	N.D.	mg/L	0.01
Di-n-butyl phthalate	N.D.	mg/L	0.01
2,4-Dinitrotoluene	N.D.	mg/L	0.01
2,6-Dinitrotoluene	N.D.	mg/L	0.01
Di-n-octyl phthalate	N.D.	mg/L	0.01
Fluoranthene	N.D.	mg/L	0.01
Fluorene	N.D.	mg/L	0.01
Hexachlorobenzene	N.D.	mg/L	0.01
Hexachlorobutadiene	N.D.	mg/L	0.01
Hexachlorocyclopentadiene	N.D.	mg/L	0.01
Hexachloroethane	N.D.	mg/L	0.01
Indeno(1,2,3-cd)pyrene	N.D.	mg/L	0.01
Isophorone	N.D.	mg/L	0.01
2-Nitroaniline	N.D.	mg/L	0.05
3-Nitroaniline	N.D.	mg/L	0.05
4-Nitroaniline	N.D.	mg/L	0.05
Nitrobenzene	N.D.	mg/L	0.01
N-Nitrosodi-n-propylamine	N.D.	mg/L	0.01

TABLE 38 (CONT'D)

RAW SLUDGE

HSL SEMIVOLATILE ORGANICS
TCLP AQUEOUS LEACHATE

Parameter	Results	Units	Reporting Limit
N-Nitrosodiphenylamine*	N.D.	mg/L	0.01
Phenanthrene	N.D.	mg/L	0.01
Pyrene	N.D.	mg/L	0.01
1,2,4-Trichlorobenzene	N.D.	mg/L	0.01
Benzoic acid	N.D.	mg/L	0.05
2-Chlorophenol	N.D.	mg/L	0.01
2,4-Dichlorophenol	N.D.	mg/L	0.01
4,6-Dinitro-2-methylphenol	N.D.	mg/L	0.05
2,4-Dinitrophenol	N.D.	mg/L	0.05
2-Nitrophenol	N.D.	mg/L	0.01
4-Nitrophenol	N.D.	mg/L	0.05
4-Chloro-3-methylphenol	N.D.	mg/L	0.01
Pentachlorophenol	N.D.	mg/L	0.01
2,4,5-Trichlorophenol	N.D.	mg/L	0.01
2,4,6-Trichlorophenol	N.D.	mg/L	0.01
Pyridine	N.D.	mg/L	0.0
Indene	N.D.	mg/L	0.01
Benzenethiol	N.D.	mg/L	0.01
7,12-Dimethylbenzanthracene	N.D.	mg/L	0.01
Quinoline	N.D.	mg/L	0.01
1-Methy napththalene	N.D.	mg/L	0.01

Sampled: 02/27/87
Analyzed: 04/22/87

N.D. = Not detected

TABLE 39

RAW SLUDGE

PCBs
TCLP AQUEOUS LEACHATE
EPA METHOD 608

Parameter	Results	Units	Reporting Limit
Aroclor 1016	N.D.	ug/L	12
Aroclor 1221	N.D.	ug/L	2.4
Aroclor 1232	N.D.	ug/L	2.4
Aroclor 1242	N.D.	ug/L	2.4
Aroclor 1248	N.D.	ug/L	3.0
Aroclor 1254	N.D.	ug/L	5.0
Aroclor 1260	N.D.	ug/L	5.0

Sampled: 02/27/87
Analyzed: 04/15/87

N.D. = Not detected

SECTION 12

ANALYTES NOT DETECTED

IN

PRODUCT SOLIDS

TABLE 40

PRODUCT SOLIDS

VOLATILE COMPOUNDS
EPA METHOD 608

CAS NUMBER	PARAMETER	RESULTS	UNITS	REPORTING LIMIT
74-83-3	Chloroethane	N.D.	ug/L	2700
-83-9	Bromomethane	N.D.	ug/L	2700
75-01-4	VinylChloride	N.D.	ug/L	2700
75-00-3	Chloroethane	N.D.	ug/L	2700
75-15-10	CarbonDisulfide	N.D.	ug/L	1400
75-35-4	1,1-Dichloroethene	N.D.	ug/L	1400
75-34-3	1,1-Dichloroethane	N.D.	ug/L	1400
156-60-5	Trans-1,2-Dichloroethene	N.D.	ug/L	1400
67-66-3	Chloroform	N.D.	ug/L	1400
107-06-2	1,2-Dichloroethane	N.D.	ug/L	1400
78-93-3	2-Butanone	N.D.	ug/L	2700
71-55-6	1,1,1-Trichloroethane	N.D.	ug/L	1400
56-23-5	CarbonTetrachloride	N.D.	ug/L	1400
108-05-4	VinylAcetate	N.D.	ug/L	2700
75-27-4	Bromodichloromethane	N.D.	ug/L	1400
79-34-5	1,1,2,2-Tetrachloroethane	N.D.	ug/L	1400
78-87-5	1,2-Dichloropropane	N.D.	ug/L	1400
10061-02-6	Trans-1,3-Dichloropropene	N.D.	ug/L	1400
124-48-1	Dibromochloromethane	N.D.	ug/L	1400
79-00-5	1,1,2-Trichloroethane	N.D.	ug/L	1400
10061-01-5	cis-1,3-Dichlorpropene	N.D.	ug/L	1400
110-75-8	2-Chloroethylvinylether	N.D.	ug/L	2700
75-25-2	Bromoform	N.D.	ug/L	1400
591-78-6	2-Hexanone	N.D.	ug/L	2700
108-10-1	4-Methyl-2-Pentanone	N.D.	ug/L	2700
108-90-7	Chlorobenzene	N.D.	ug/L	1400
100-42-5	Styrene	N.D.	ug/L	1400

TABLE 41

PRODUCT SOLIDS

SEMIVOLATILE COMPOUNDS
EPA METHOD 608

PARAMETER	CAS NUMBER	RESULTS	UNITS	REPORTING LIMIT
111-4-4	bis(-2-Chloroethyl)Ether	N.D.	ug/L	19000
95-57-8	2-Chlorophenol	N.D.	ug/L	19000
541-73-1	1,3-Dichlorobenzene	N.D.	ug/L	19000
106-46-7	1,4-Dichlorobenzene	N.D.	ug/L	19000
100-51-6	Benzyl Alcohol	N.D.	ug/L	19000
35-48-7	2-Methylphenol	N.D.	ug/L	19000
39638-32-9	bis(2-chloroisopropyl)Ether	N.D.	ug/L	19000
881-64-7	N-Nitro-Di-n-Propylamine	N.D.	ug/L	19000
72-1	Hexachloroethane	N.D.	ug/L	19000
58-95-3	Nitrobenzene	N.D.	ug/L	19000
78-59-1	Isophorone	N.D.	ug/L	19000
88-75-5	2-Nitrophenol	N.D.	ug/L	19000
120-83-2	2,4-Dichlorophenol	N.D.	ug/L	19000
111-91-1	bis(2-Chloroethoxy) Methane	N.D.	ug/L	19000
120-83-2	2,4-Dichlorophenol	N.D.	ug/L	19000
120-82-1	1,2,4-Trichlorobenzene	N.D.	ug/L	19000
106-47-8	4-Chloroaniline	N.D.	ug/L	19000
87-68-3	Hexachlorobutadiene	N.D.	ug/L	19000
77-47-4	Hexachlorocyclopentadiene	N.D.	ug/L	19000
88-66-2	2,4,6-Trichlorophenol	N.D.	ug/L	19000
95-95-4	2,4,5-Trichlorophenol	N.D.	ug/L	90000
91-58-7	2-Chloronaphthalene	N.D.	ug/L	19000
88-74-4	2-Nitroaniline	N.D.	ug/L	90000
131-11-4	Dimethyl Phthalate	N.D.	ug/L	19000
208-96-8	Acenaphthyleme	N.D.	ug/L	19000
99-09-2	3-Nitroaniline	N.D.	ug/L	90000
83-32-9	Acenaphthene	N.D.	ug/L	19000
51-28-5	2,4-Dinitrophenol	N.D.	ug/L	90000
100-02-7	4-Nitrophenol	N.D.	ug/L	90000
132-64-9	Dibenzofuran	N.D.	ug/L	19000
121-14-2	2,4-Dinitrotoluene	N.D.	ug/L	19000
606-20-2	2,6-Dinitrotoluene	N.D.	ug/L	19000
84-66-2	Diethylphthalate	N.D.	ug/L	19000
7005-72-3	4-Chlorophenyl-phenylether	N.D.	ug/L	19000

TABLE 41 (CONT'D)

PRODUCT SOLIDS

SEMIVOLATILE COMPOUNDS
EPA METHOD 608

PARAMETER	CAS NUMBER	RESULTS	UNITS	REPORTING LIMIT
100-01-6	4-Nitroaline	N.D.	ug/L	90000
534-52-1	4,6-Dinitro-2-Methylphenol	N.D.	ug/L	90000
101-55-3	4-Bromophenyl-phenyletheer	N.D.	ug/L	19000
118-74-1	Hexachlorobenzene	N.D.	ug/L	19000
87-86-5	Pentachlorophenol	N.D.	ug/L	90000
120-12-7	Anthracene	N.D.	ug/L	19000
84-74-2	Di-N-Butylphthalate	N.D.	ug/L	19000
91-94-1	3,3'-Dichlorobenzidine	N.D.	ug/L	37000
56-55-3	Benzo(a)Anthracene	N.D.	ug/L	19000
117-84-0	Di-n-Octylphthalate	N.D.	ug/L	19000
205-99-2	Benzo(b)Fluoranthene	N.D.	ug/L	19000
207-08-9	Benzo(k)Fluoranthene	N.D.	ug/L	19000
50-32-8	Benzo(a)Pyrene	N.D.	ug/L	19000
193-39-5	Indenol(1,2,3-cd)Pyrene	N.D.	ug/L	19000
53-70-3	Dibenzo(a,h)Anthracene	N.D.	ug/L	19000
191-24-2	Benzo(g,h,i)Perylene	N.D.	ug/L	19000

TABLE 42

PRODUCT SOLIDS

HSL VOLATILE ORGANICS
TCLP AQUEOUS LEACHATE
EPA METHOD 624

Parameter	Results	Units	Reporting Limit
Acetone	N.D.	mg/L	0.12
Bromoform	N.D.	mg/L	0.025
Bromomethane	N.D.	mg/L	0.025
2-Butanone	N.D.	mg/L	0.12
Carbon disulfide	N.D.	mg/L	0.025
Carbon tetrachloride	N.D.	mg/L	0.025
Chlorobenzene	N.D.	mg/L	0.025
Chlorodibromoethane	N.D.	mg/L	0.025
Chloroethane	N.D.	mg/L	0.05
2-Chloroethylvinyl ether	N.D.	mg/L	0.05
Chloroform	N.D.	mg/L	0.025
Chloromethane	N.D.	mg/L	0.05
Dichlorobromomethane	N.D.	mg/L	0.025
1,1-Dichloroethane	N.D.	mg/L	0.025
1,2-Dichloroethane	N.D.	mg/L	0.025
1,1-Dichloroethylene	N.D.	mg/L	0.025
1,2-Dichloropropane	N.D.	mg/L	0.025
cis-1,3-Dichloropropene	N.D.	mg/L	0.025
trans-1,3-Dichloropropene	N.D.	mg/L	0.025
2-Hexanone	N.D.	mg/L	0.05
Methlylene chloride	N.D.	mg/L	0.05
Styrene	N.D.	mg/L	0.025
1,1,2,2-Tetrachloroethane	N.D.	mg/L	0.025
Tetrachloroethene	N.D.	mg/L	0.025
1,2-trans-Dichloroethylene	N.D.	mg/L	0.025
1.1.1-Trichloroethane	N.D.	mg/L	0.025
1,1,2-Trichloroethane	N.D.	mg/L	0.025
Trichloroethene	N.D.	mg/L	0.025
Vinyl Acetate	N.D.	mg/L	0.05
Vinyl chloride	N.D.	mg/L	0.05
1-4-Dioxane	N.D.	mg/L	0.5
1-2-Dibromoethane	N.D.	mg/L	0.025

Sampled: 02/26/87
Analyzed: 04/07/87

N.D. = Not detected

TABLE 43

PRODUCT SOLIDS

HSL SEMIVOLATILE ORGANICS
TCLP AQUEOUS LEACHATE

Parameter	Results	Units	Reporting Limit
Acenaphthene	N.D.	mg/L	0.01
Acenaphthylene	N.D.	mg/L	0.01
Anthracene	N.D.	mg/L	0.01
Benzo(a)anthracene	N.D.	mg/L	0.01
Benzo(a)pyrene	N.D.	mg/L	0.01
Benzo(b)fluoranthene	N.D.	mg/L	0.01
Benzo(g,h,i)perylene	N.D.	mg/L	0.01
Benzo(k)fluoranthene	N.D.	mg/L	0.01
Benzyl alcohol	N.D.	mg/L	0.01
Bis(2-chloroethoxy)methane	N.D.	mg/L	0.01
Bis(2-chloroethyl)ether	N.D.	mg/L	0.01
Bis(2-chloroisopropyl)ether	N.D.	mg/L	0.01
Bis(2-ethylhexyl)phthalate	N.D.	mg/L	0.01
4-Bromophenyl phenyl ether	N.D.	mg/L	0.01
Butylbenzyl phthalate	N.D.	mg/L	0.01
4-Chloroaniline	N.D.	mg/L	0.01
2-Chloronaphthalene	N.D.	mg/L	0.01
4-Chlorophenyl phenyl ether	N.D.	mg/L	0.01
Chrysene	N.D.	mg/L	0.01
Dibenz(a,h)anthracene	N.D.	mg/L	0.01
Dibenzofuran	N.D.	mg/L	0.01
1,2-Dichlorobenzene	N.D.	mg/L	0.01
1,3-Dichlorobenzene	N.D.	mg/L	0.01
1,4-Dichlorobenzene	N.D.	mg/L	0.01
3,3'-Dichlorobensidine	N.D.	mg/L	0.04
Diethyl phthalate	N.D.	mg/L	0.01
Dimethyl phthalate	N.D.	mg/L	0.01
Di-n-butyl phthalate	N.D.	mg/L	0.01
2,4-Dinitrotoluene	N.D.	mg/L	0.01
2,6-Dinitrotoluene	N.D.	mg/L	0.01
Di-n-octyl phthalate	N.D.	mg/L	0.01
Fluoranthene	N.D.	mg/L	0.01
Fluorene	N.D.	mg/L	0.01
Hexachlorobenzene	N.D.	mg/L	0.01
Hexachlorobutadiene	N.D.	mg/L	0.01
Hexachlorocyclopentadiene	N.D.	mg/L	0.01
Hexachloroethane	N.D.	mg/L	0.01
Indeno(1,2,3-cd)pyrene	N.D.	mg/L	0.01
Isophorone	N.D.	mg/L	0.01
2-Nitroaniline	N.D.	mg/L	0.05
3-Nitroaniline	N.D.	mg/L	0.05
4-Nitroaniline	N.D.	mg/L	0.05
Nitrobenzene	N.D.	mg/L	0.01

TABLE 43 (CONT'D)

PRODUCT SOLIDS

HSL SEMIVOLATILE ORGANICS
TCLP AQUEOUS LEACHATE

Parameter	Results	Units	Reporting Limit
N-Nitrosodi-n-propylamine	N.D.	mg/L	0.01
N-Nitrosodiphenylamine*	N.D.	mg/L	0.01
Phenanthrene	N.D.	mg/L	0.01
Pyrene	N.D.	mg/L	0.01
1,2,4-Trichlorobenzene	N.D.	mg/L	0.01
Benzoic acid	N.D.	mg/L	0.05
2-Chlorophenol	N.D.	mg/L	0.01
2,4-Dichlorophenol	N.D.	mg/L	0.01
4,6-Dinitro-2-methylphenol	N.D.	mg/L	0.05
2,4-Dinitrophenol	N.D.	mg/L	0.05
2-Nitrophenol	N.D.	mg/L	0.01
4-Nitrophenol	N.D.	mg/L	0.05
4-Chloro-3-methylphenol	N.D.	mg/L	0.01
Pentachlorophenol	N.D.	mg/L	0.01
2,4,5-Trichlorophenol	N.D.	mg/L	0.01
2,4,6-Trichlorophenol	N.D.	mg/L	0.01
Pyridine	N.D.	mg/L	0.0
Indene	N.D.	mg/L	0.01
Benzenethiol	N.D.	mg/L	0.01
7,12-Dimethylbenzanthracene	N.D.	mg/L	0.01
Quinoline	N.D.	mg/L	0.01
1-Methy napththalene	N.D.	mg/L	0.01

Sampled: 02/27/87
Analyzed: 04/22/87

N.D. = Not detected

B.76

TABLE 44

PRODUCT SOLIDS

PESTICIDES/PCB'S
EPA METHOD 608

CAS NUMBER	PARAMETER	RESULTS	UNITS	REPORTING LIMIT
319-84-6	Alpha-BHC	N.D.	ug/L	86.0
319-85-7	Beta-BHC	N.D.	ug/L	86.0
319-86-8	Delta-BHC	N.D.	ug/L	86.0
58-89-9	Gamma-BHC (Lindane)	N.D.	ug/L	86.0
76-44-8	Heptachlor	N.D.	ug/L	86.0
309-00-2	Aldrin	N.D.	ug/L	86.0
1204-57-3	Heptachlor Epoxide	N.D.	ug/L	86.0
959-98-8	Endosulfan I	N.D.	ug/L	86.0
60-57-1	Dieldrin	N.D.	ug/L	170.0
72-55-9	4,4'-DDE	N.D.	ug/L	170.0
72-20-8	Endrin	N.D.	ug/L	170.0
33213-65-9	Endosulfan II	N.D.	ug/L	170.0
72-54-8	4,4'-DDD	N.D.	ug/L	170.0
1031-07-8	Endosulfan Sulfate	N.D.	ug/L	170.0
50-29-3	4,4'-DDT	N.D.	ug/L	170.0
72-43-5	Methoxychlor	N.D.	ug/L	860.0
53494-70-5	Endrin Ketone	N.D.	ug/L	170.0
57-74-9	Chlordane	N.D.	ug/L	860.0
8001-35-2	Toxaphene	N.D.	ug/L	1700.0
12674-11-2	Aroclor-1016	N.D.	ug/L	860.0
11104-28-2	Aroclor-1221	N.D.	ug/L	860.0
11141-16-5	Aroclor-1232	N.D.	ug/L	860.0
53469-21-9	Aroclor-1242	N.D.	ug/L	860.0
12672-29-6	Aroclor-1248	N.D.	ug/L	860.0
11097-69-1	Aroclor-1254	N.D.	ug/L	1700.0
11096-82-5	Aroclor-1260	N.D.	ug/L	1700.0

SECTION 13

ANALYTES NOT DETECTED
IN
RAW PRODUCT WATER

TABLE 45

RAW PRODUCT WATER

VOLATILE COMPOUNDS
EPA METHOD 608

CAS NUMBER	PARAMETER	RESULTS	UNITS	REPORTING LIMIT
3-9	Bromomethane	N.D.	ug/L	1000
75-01-4	VinylChloride	N.D.	ug/L	1000
75-00-3	Chloroethane	N.D.	ug/L	1000
75-15-0	CarbonDisulfide	N.D.	ug/L	500
75-35-4	1,1-Dichloroethene	N.D.	ug/L	500
75-34-3	1,1-Dichloroethane	N.D.	ug/L	500
156-60-5	Trans-1,2-Dichloroethene	N.D.	ug/L	500
67-66-3	Chloroform	N.D.	ug/L	500
107-66-2	1,2-Dichloroethane	N.D.	ug/L	500
71-55-6	1,1,1-Trichloroethane	N.D.	ug/L	500
56-23-5	CarbonTetrachloride	N.D.	ug/L	500
108-05-4	VinylAcetate	N.D.	ug/L	1000
75-27-4	Bromodichloromethane	N.D.	ug/L	500
79-34-5	1,1,2,2-Tetrachloroethane	N.D.	ug/L	500
78-87-5	1,2-Dichloropropane	N.D.	ug/L	500
10061-02-6	Trans-1,3-Dichloropropene	N.D.	ug/L	500
79-10-6	Trichloroethene	N.D.	ug/L	500
124-48-1	Dibromochloromethane	N.D.	ug/L	500
79-00-5	1,1,2-Trichloroethane	N.D.	ug/L	500
71-43-2	Benzene	N.D.	ug/L	500
10061-01-5	cis-1,3-Dichloropropene	N.D.	ug/L	500
110-75-8	2-Chloroethylvinylether	N.D.	ug/L	1000
75-25-2	Bromoform	N.D.	ug/L	500
591-78-6	2-Hexanone	N.D.	ug/L	1000
108-10-1	4-Methyl-2-Pentanone	N.D.	ug/L	1000
127-18-4	Tetrachloroethene	N.D.	ug/L	500
108-88-3	Toluene	N.D.	ug/L	500
108-90-7	Chlorobenzene	N.D.	ug/L	500
100-41-4	Ethylbenzene	N.D.	ug/L	500
100-42-5	Styrene	N.D.	ug/L	500

TABLE 46

RAW PRODUCT WATER

SEMIVOLATILE COMPOUNDS
EPA METHOD 608

CAS NUMBER	PARAMETER	RESULTS	UNITS	REPORTING LIMIT
111-44-4	bis(-2-Chloroethyl)Ether	N.D.	ug/L	130
95-57-8	2-Chlorophenol	N.D.	ug/L	670
541-73-1	1,3-Dichlorobenzene	N.D.	ug/L	670
106-46-7	1,4-Dichlorobenzene	N.D.	ug/L	130
100-51-6	Benzyl Alcohol	N.D.	ug/L	130
95-48-7	2-Methylphenol	N.D.	ug/L	130
39638-32-9	bis(2-chloroisopropyl)Ether	N.D.	ug/L	130
621-64-7	N-Nitro-Di-n-Propylamine	N.D.	ug/L	670
-72-1	Hexachloroethane	N.D.	ug/L	670
38-95-3	Nitrobenzene	N.D.	ug/L	130
78-59-1	Isophorone	N.D.	ug/L	130
88-75-5	2-Nitrophenol	N.D.	ug/L	130
111-91-1	bis(2-Chloroethoxy) Methane	N.D.	ug/L	130
120-83-2	2,4-Dichlorophenol	N.D.	ug/L	130
120-82-1	1,2,4-Trichlorobenzene	N.D.	ug/L	130
106-47-8	4-Chloroaniline	N.D.	ug/L	130
87-68-3	Hexachlorobutadiene	N.D.	ug/L	270
77-47-4	Hexachlorocyclopentadiene	N.D.	ug/L	130
88-06-2	2,4,6-Trichlorophenol	N.D.	ug/L	130
95-95-4	2,4,5-Trichlorophenol	N.D.	ug/L	130
91-58-7	2-Chloronaphthalene	N.D.	ug/L	130
88-74-4	2-Nitroaniline	N.D.	ug/L	130
131-11-4	Dimethyl Phthalate	N.D.	ug/L	130
208-96-8	Acenaphthyleme	N.D.	ug/L	130
99-09-2	3-Nitroaniline	N.D.	ug/L	130
83-32-9	Acenaphthene	N.D.	ug/L	130
51-28-5	2,4-Dinitrophenol	N.D.	ug/L	670
100-02-7	4-Nitrophenol	N.D.	ug/L	130
132-64-9	Dibenzofuran	N.D.	ug/L	130
121-14-2	2,4-Dinitrotoluene	N.D.	ug/L	130
606-20-2	2,6-Dinitrotoluene	N.D.	ug/L	130
84-66-2	Diethylphthalate	N.D.	ug/L	130
7005-72-3	4-Chlorophenyl-phenylether	N.D.	ug/L	130

TABLE 46 (CONT'D)

RAW PRODUCT WATER

SEMIVOLATILE COMPOUNDS
EPA METHOD 608

CAS NUMBER	PARAMETER	RESULTS	UNITS	REPORTING LIMIT
100-01-6	4-Nitroaniline	N.D.	ug/L	670
534-52-1	4,6-Dinitro-2-Methylphenol	N.D.	ug/L	670
101-55-3	4-Bromophenyl-phenylether	N.D.	ug/L	130
118-74-1	Hexachlorobenzene	N.D.	ug/L	130
87-86-5	Pentachlorophenol	N.D.	ug/L	670
120-12-7	Anthracene	N.D.	ug/L	130
84-74-2	Di-N-Butylphthalate	N.D.	ug/L	130
91-94-1	3,3'-Dichlorobenzidine	N.D.	ug/L	270
56-55-3	Benzo(a)Anthraccene	N.D.	ug/L	130
117-84-0	Di-n-Octylphthalate	N.D.	ug/L	130
205-99-2	Benzo(b)Fluoranthene	N.D.	ug/L	130
207-08-9	Benzo(k)Fluoranthene	N.D.	ug/L	130
50-32-8	Benzo(a)Pyrene	N.D.	ug/L	130
193-39-5	Indeno(1,2,3-cd)Pyrene	N.D.	ug/L	130
53-70-3	Dibenzo(a,h)Anthracene	N.D.	ug/L	130
191-24-2	Benzo(g,h,i)Perylene	N.D.	ug/L	130

TABLE 47

RAW PRODUCT WATER

PCBs
PESTICIDES
EPA METHOD 608

CAS NUMBER	PARAMETER	RESULTS	UNITS	REPORTING LIMIT
319-84-6	Alpha-BHC	N.D.	ug/L	0.06
319-85-7	Beta-BHC	N.D.	ug/L	0.06
319-86-8	Delta-BHCO	N.D.	ug/L	0.06
58-89-9	Gamma-BHC (Lindane)	N.D.	ug/L	0.06
76-44-8	Heptachlor	N.D.	ug/L	0.06
309-00-2	Aldrin	N.D.	ug/L	0.06
1204-57-3	Heptachlor Epoxide	N.D.	ug/L	0.06
959-98-8	Endosulfan I	N.D.	ug/L	0.06
60-57-1	Dieldrin	N.D.	ug/L	0.13
72-55-9	4,4'-DDE	N.D.	ug/L	0.13
72-20-8	Endrin	N.D.	ug/L	0.13
33213-65-9	Endosulfan II	N.D.	ug/L	0.13
72-54-8	4,4'-DDD	N.D.	ug/L	0.13
1031-07-8	Endosulfan Sulfate	N.D.	ug/L	0.13
50-29-3	4,4'-DDT	N.D.	ug/L	0.13
72-43-5	Methoxychlor	N.D.	ug/L	0.63
53494-70-5	Endrin Ketone	N.D.	ug/L	0.13
57-74-9	Chlordane	N.D.	ug/L	0.63
8001-35-2	Toxaphene	N.D.	ug/L	1.30
12674-11-2	Aroclor-1016	N.D.	ug/L	0.63
11104-28-2	Aroclor-1221	N.D.	ug/L	0.63
11141-16-5	Aroclor-1232	N.D.	ug/L	0.63
53469-21-9	Aroclor-1242	N.D.	ug/L	0.63
12672-29-6	Aroclor-1248	N.D.	ug/L	0.63
11097-69-1	Aroclor-1254	N.D.	ug/L	1.30
11096-82-5	Aroclor-1260	N.D.	ug/L	1.30

SECTION 14

ANALYTES NOT DETECTED IN TREATED PRODUCT WATER

TABLE 48

TREATED PRODUCT WATER

VOLATILE COMPOUNDS
EPA METHOD 608

CAS NUMBER	PARAMETER	RESULTS	UNITS	REPORTING LIMIT
74-83-3	Chloroethane	N.D.	ug/L	500
- 3-9	Bromomethane	N.D.	ug/L	500
75-01-4	VinylChloride	N.D.	ug/L	500
75-00-3	Chloroethane	N.D.	ug/L	500
75-15-10	CarbonDisulfide	N.D.	ug/L	250
75-35-4	1,1-Dichloroethene	N.D.	ug/L	250
75-34-3	1,1-Dichloroethane	N.D.	ug/L	500
156-60-5	Trans-1,2-Dichloroethene	N.D.	ug/L	250
67-66-3	Chloroform	N.D.	ug/L	500
71-55-6	1,1,1-Trichloroethane	N.D.	ug/L	250
56-23-5	CarbonTetrachloride	N.D.	ug/L	250
108-05-4	VinylAcetate	N.D.	ug/L	500
75-27-4	Bromodichloromethane	N.D.	ug/L	250
79-34-5	1,1,2,2-Tetrachloroethane	N.D.	ug/L	250
78-87-5	1,2-Dichloropropane	N.D.	ug/L	250
10061-02-6	Trans-1,3-Dichloropropene	N.D.	ug/L	250
79-10-6	Trichloroethene	N.D.	ug/L	250
124-48-1	Dibromochloromethane	N.D.	ug/L	250
79-00-5	1,1,2-Trichloroethane	N.D.	ug/L	250
71-43-2	Benzene	N.D.	ug/L	250
10061-01-5	cis-1,2-Dichlorpropene	N.D.	ug/L	250
110-75-8	2-Chloroethylvinylether	N.D.	ug/L	500
75-25-2	Bromoform	N.D.	ug/L	250
591-78-6	2-Hexanone	N.D.	ug/L	500
108-10-1	4-Methyl-2-Pentanone	N.D.	ug/L	500
127-18-4	Tetrachloroethene	N.D.	ug/L	250
108-88-3	Toluene	N.D.	ug/L	250
108-90-7	Chlorobenzene	N.D.	ug/L	250
100-41-4	Ethylbenzene	N.D.	ug/L	250
100-42-5	Styrene	N.D.	ug/L	250

TABLE 49

TREATED PRODUCT WATER

SEMIVOLATILE COMPOUNDS
EPA METHOD 608

PARAMETER	CAS NUMBER	RESULTS	UNITS	REPORTING LIMIT
111-4-4	bis(-2-Chloroethyl)Ether	N.D.	ug/L	200
95-57-8	2-Chlorophenol	N.D.	ug/L	200
541-73-1	1,3-Dichlorobenzene	N.D.	ug/L	200
106-46-7	1,4-Dichlorobenzene	N.D.	ug/L	200
100-51-6	Benzyl Alcohol	N.D.	ug/L	200
35-48-7	2-Methylphenol	N.D.	ug/L	200
39638-32-9	bis(2-chloroisopropyl)Ether	N.D.	ug/L	200
881-64-7	N-Nitro-Di-n-Propylamine	N.D.	ug/L	200
72-1	Hexachloroethane	N.D.	ug/L	200
58-95-3	Nitrobenzene	N.D.	ug/L	200
78-59-1	Isophorone	N.D.	ug/L	200
88-75-5	2-Nitrophenol	N.D.	ug/L	200
111-91-1	bis(2-Chloroethoxy) Methane	N.D.	ug/L	200
120-83-2	2,4-Dichlorophenol	N.D.	ug/L	200
120-82-1	1,2,4-Trichlorobenzene	N.D.	ug/L	200
106-47-8	4-Chloroaniline	N.D.	ug/L	200
87-68-3	Hexachlorobutadiene	N.D.	ug/L	200
77-47-4	Hexachlorocyclopentadiene	N.D.	ug/L	200
88-66-2	2,4,6-Trichlorophenol	N.D.	ug/L	200
95-95-4	2,4,5-Trichlorophenol	N.D.	ug/L	1000
91-58-7	2-Chloronaphthalene	N.D.	ug/L	200
88-74-4	2-Nitroaniline	N.D.	ug/L	1000
131-11-4	Dimethyl Phthalate	N.D.	ug/L	200
208-96-8	Acenaphthyleme	N.D.	ug/L	200
99-09-2	3-Nitroaniline	N.D.	ug/L	1000
83-32-9	Acenaphthene	N.D.	ug/L	200
51-28-5	2,4-Dinitrophenol	N.D.	ug/L	1000
100-02-7	4-Nitrophenol	N.D.	ug/L	1000
132-64-9	Dibenzofuran	N.D.	ug/L	200
121-14-2	2,4-Dinitrotoluene	N.D.	ug/L	200
606-20-2	2,6-Dinitrotoluene	N.D.	ug/L	200
84-66-2	Diethylphthalate	N.D.	ug/L	200
7005-72-3	4-Chlorophenyl-phenylether	N.D.	ug/L	200

TABLE 49 (CONT'D)

TREATED PRODUCT WATER

SEMIVOLATILE COMPOUNDS
EPA METHOD 608

PARAMETER	CAS NUMBER	RESULTS	UNITS	REPORTING LIMIT
100-01-6	4-Nitroaline	N.D.	ug/L	1000
534-52-1	4,6-Dinitro-2-Methylphenol	N.D.	ug/L	1000
101-55-3	4-Bromophenyl-phenyletheer	N.D.	ug/L	200
118-74-1	Hexachlorobenzene	N.D.	ug/L	200
87-86-5	Pentachlorophenol	N.D.	ug/L	1000
120-12-7	Anthracene	N.D.	ug/L	200
84-74-2	Di-N-Butylphthalate	N.D.	ug/L	200
91-94-1	3,3'-Dichlorobenzidine	N.D.	ug/L	400
56-55-3	Benzo(a)Anthracene	N.D.	ug/L	200
117-84-0	Di-n-Octylphthalate	N.D.	ug/L	200
205-99-2	Benzo(b)Fluoranthene	N.D.	ug/L	200
207-08-9	Benzo(k)Fluoranthene	N.D.	ug/L	200
50-32-8	Benzo(a)Pyrene	N.D.	ug/L	200
193-39-5	Indeno(1,2,3-cd)Pyrene	N.D.	ug/L	200
53-70-3	Dibenzo(a,h)Anthracene	N.D.	ug/L	200
191-24-2	Benzo(g,h,i)Perylene	N.D.	ug/L	200

TABLE 50

TREATED PRODUCT WATER

PESTICIDES/PCB'S
EPA METHOD 608

CAS NUMBER	PARAMETER	RESULTS	UNITS	REPORTING LIMIT
319-84-6	Alpha-BHC	N.D.	ug/L	0.17
319-85-7	Beta-BHC	N.D.	ug/L	0.17
319-86-8	Delta-BHC	N.D.	ug/L	0.17
58-89-9	Bamma-BHC (Lindane)	N.D.	ug/L	0.17
76-44-8	Heptachlor	N.D.	ug/L	0.17
309-00-2	Aldrin	N.D.	ug/L	0.17
1204-57-3	Heptachlor Epoxide	N.D.	ug/L	0.17
959-98-8	Endosulfan I	N.D.	ug/L	0.17
60-57-1	Dieldrin	N.D.	ug/L	0.33
72-55-9	4,4'-DDE	N.D.	ug/L	0.33
72-20-8	Endrin	N.D.	ug/L	0.33
33213-65-9	Endosulfan II	N.D.	ug/L	0.33
72-54-8	4,4'-DDD	N.D.	ug/L	0.33
1031-07-8	Endosulfan Sulfate	N.D.	ug/L	0.33
50-29-3	4,4'-DDT	N.D.	ug/L	0.33
72-43-5	Methoxychlor	N.D.	ug/L	1.70
53494-70-5	Endrin Ketone	N.D.	ug/L	0.33
57-74-9	Chlordane	N.D.	ug/L	1.70
8001-35-2	Toxaphene	N.D.	ug/L	3.30
12674-11-2	Aroclor-1016	N.D.	ug/L	1.70
11104-28-2	Aroclor-1221	N.D.	ug/L	1.70
11141-16-5	Aroclor-1232	N.D.	ug/L	1.70
53469-21-9	Aroclor-1242	N.D.	ug/L	1.70
12672-29-6	Aroclor-1248	N.D.	ug/L	1.70
11097-69-1	Aroclor-1254	N.D.	ug/L	1.30
11096-82-5	Aroclor-1260	N.D.	ug/L	1.30

SECTION 15

ANALYTES NOT DETECTED
IN
PRODUCT OIL

TABLE 51

PRODUCT OIL

HSL VOLATILE ORGANICS
TCLP AQUEOUS LEACHATE
EPA METHOD 624

Parameter	Results	Units	Reporting Limit
Acetone	N.D.	mg/L	12.5
Benzene	N.D.	mg/L	1.25
Bromoform	N.D.	mg/L	1.25
Bromomethane	N.D.	mg/L	2.5
2-Butanone	N.D.	mg/L	12.5
Carbon disulfide	N.D.	mg/L	1.25
Carbon tetrachloride	N.D.	mg/L	1.25
Chlorobenzene	N.D.	mg/L	1.25
Dibromochloromethane	N.D.	mg/L	1.25
Chlorodibromoethane	N.D.	mg/L	1.25
Chloroethane	N.D.	mg/L	2.5
2-Chloroethylvinyl ether	N.D.	mg/L	2.5
Chloroform	N.D.	mg/L	1.25
Chloromethane	N.D.	mg/L	2.5
Bromodichloromethane	N.D.	mg/L	1.25
1,1-Dichloroethane	N.D.	mg/L	1.25
1,2-Dichloroethane	N.D.	mg/L	1.25
1,1-Dichloroethylene	N.D.	mg/L	1.25
1,2-Dichloropropane	N.D.	mg/L	1.25
cis-1,3-Dichloropropene	N.D.	mg/L	1.25
trans-1,3-Dichloropropene	N.D.	mg/L	1.25
2-Hexanone	N.D.	mg/L	2.5
Methlylene chloride	N.D.	mg/L	2.5
4-Methyl-2-pentanone	N.D.	mg/L	2.5
Styrene	N.D.	mg/L	1.25
1,1,2,2-Tetrachloroethane	N.D.	mg/L	1.25
Tetrachloroethene	N.D.	mg/L	1.25
Trans-1,2-Dichloroethylene	N.D.	mg/L	1.25
1,1,1-Trichloroethane	N.D.	mg/L	1.25
1,1,2-Trichloroethane	N.D.	mg/L	1.25
Trichloroethene	N.D.	mg/L	1.25
Vinyl acetate	N.D.	mg/L	2.5
Vinyl chloride	N.D.	mg/L	2.5

Sampled: 02/26/87
Analyzed: 04/10/87

N.D. = Not detected

TABLE 52

PRODUCT OIL

HSL SEMIVOLATILE ORGANICS
TCLP AQUEOUS LEACHATE

Parameter	Results	Units	Reporting Limit
Acenaphthylene	N.D.	mg/L	20
Benzo(a)anthracene	N.D.	mg/L	20
Benzo(a)pyrene	N.D.	mg/L	20
Benzo(b)fluoranthene	N.D.	mg/L	20
Benzo(g,h,i)perylene	N.D.	mg/L	20
Benzo(k)fluoranthene	N.D.	mg/L	20
Benzyl alcohol	N.D.	mg/L	20
Bis(2-chloroethoxy)methane	N.D.	mg/L	20
Bis(2-chloroethyl)ether	N.D.	mg/L	20
Bis(2-chloroisopropyl)ether	N.D.	mg/L	20
4-Bromophenyl phenyl ether	N.D.	mg/L	20
Butylbenzyl phthalate	N.D.	mg/L	20
4-Chloroaniline	N.D.	mg/L	20
2-Chloronaphthalene	N.D.	mg/L	20
4-Chlorophenyl phenyl ether	N.D.	mg/L	20
Dibenz(a,h)anthracene	N.D.	mg/L	20
1,2-Dichlorobenzene	N.D.	mg/L	20
1,3-Dichlorobenzene	N.D.	mg/L	20
1,4-Dichlorobenzene	N.D.	mg/L	20
3,3'-Dichlorobensidine	N.D.	mg/L	80
Diethyl phthalate	N.D.	mg/L	20
Dimethyl phthalate	N.D.	mg/L	20
Di-n-butyl phthalate	N.D.	mg/L	20
2,4-Dinitrotoluene	N.D.	mg/L	20
2,6-Dinitrotoluene	N.D.	mg/L	20
Di-n-octyl phthalate	N.D.	mg/L	20
Fluoranthene	N.D.	mg/L	20
Hexachlorobenzene	N.D.	mg/L	20
Hexachlorobutadiene	N.D.	mg/L	20
Hexachlorocyclopentadiene	N.D.	mg/L	20
Hexachloroethane	N.D.	mg/L	20
Indeno(1,2,3-cd)pyrene	N.D.	mg/L	20
Isophorone	N.D.	mg/L	20
2-Nitroaniline	N.D.	mg/L	20
3-Nitroaniline	N.D.	mg/L	20
4-Nitroaniline	N.D.	mg/L	20
Nitrobenzene	N.D.	mg/L	20

TABLE 52 (CONT'D)

PRODUCT OIL

HSL SEMIVOLATILE ORGANICS
TCLP AQUEOUS LEACHATE

Parameter	Results	Units	Reporting Limit
N-Nitrosodi-n-propylamine	N.D.	mg/L	20
1,2,4-Trichlorobenzene	N.D.	mg/L	20
Benzoic acid	N.D.	mg/L	20
2-Chlorophenol	N.D.	mg/L	100
2,4-Dichlorophenol	N.D.	mg/L	20
2,4-Dimethylphenol	N.D.	mg/L	20
4,6-Dinitro-2-methylphenol	N.D.	mg/L	100
2,4-Dinitrophenol	N.D.	mg/L	100
2-Methylphenol	N.D.	mg/L	20
2-Nitrophenol	N.D.	mg/L	20
4-Nitrophenol	N.D.	mg/L	100
4-Chloro-3-methylphenol	N.D.	mg/L	20
Pentachlorophenol	N.D.	mg/L	20
2,4,5-Trichlorophenol	N.D.	mg/L	20
2,4,6-Trichlorophenol	N.D.	mg/L	20

Sampled: 02/26/87
Analyzed: 04/16/87

N.D. = Not detected

TABLE 53

PRODUCT OIL

PCBs
TCLP AQUEOUS LEACHATE
EPA METHOD 608

Parameter	Results	Units	Reporting Limit
Aroclor 1016	N.D.	ug/L	1.2
Aroclor 1221	N.D.	ug/L	1.2
Aroclor 1232	N.D.	ug/L	1.2
Aroclor 1242	N.D.	ug/L	1.2
Aroclor 1248	N.D.	ug/L	1.5
Aroclor 1254	N.D.	ug/L	0.50
Aroclor 1260	N.D.	ug/L	0.50

Sampled: 02/26/87
Analyzed: 04/09/87

N.D. = Not detected

SECTION 16

SAMPLE KEY

TABLE 54

SAMPLE KEY FOR B.E.S.T.^{TM} SLUDGE PROCESSING BDAT TEST

Sample Tag #	RMAL #	EPA #	Sample Description	Date	Time
1001	001		Product Oil	2/26	1405 hrs
1002	001		" "	"	"
1003	001		" "	"	"
1004	001		" "	"	"
1005	001		" "	"	"
1006	001		" "	"	"
1007	001		" "	"	"
1008	001		" "	"	"
1009	001		" "	"	"
1010	002	MJC 201	Raw Product Water	"	1515 hrs
1011	002	JB 661	" " "	"	"
1012	003	MJC 202	Product Solids	"	"
1013	004	JB 662	" "	"	1530 hrs
1014	004	JB 662	" "	"	"
1015	004	MJC 203/JB662	" "	"	"
1016	005		Raw Sludge	"	1615 hrs
1017	006		" "	"	1728 hrs
1018	072		" "	"	"
1019	007		" "	"	1745 hrs
1020	007		" "	"	"
1021	007		" "	"	"
1022	008		" "	"	1800 hrs
1023	009	JB 664	Raw Product Water	"	"
1024	009	JB 663	" " "	"	"
1025	009	JB 664	" " "	"	"
1026	009	JB 663	" " "	"	"
1027	009		" " "	"	"
1028	009	MJC 204	" " "	"	"
1029	010		Product Oil	"	1845 hrs
1030	010		" "	"	"
1031	010		" "	"	"
1032	010		" "	"	"
1033	010		" "	"	"
1034	011		Raw Sludge	"	1830 hrs
1035	012		" "	"	1845 hrs
1036	012		" "	"	"
1037	013		" "	"	2015 hrs
1038	071		Product Solids	"	1015 hrs
1039	014	MJC 205	Raw Product Water	"	2130 hrs
1040	014	JB 665	" " "	"	"
1041	015	MJC 206	" " "	"	2300 hrs
1042	015		" " "	"	"

TABLE 54 (CONT'D)

SAMPLE KEY FOR B.E.S.T.^{TM} SLUDGE PROCESSING BDAT TEST

Sample Tag #	RMAL #	EPA #	Sample Description	Date	Time
1043	016	MJC 207	Treated Product Water	2/26	2315 hrs
1044	016	JB 666	" " "	"	"
1045	016		" " "	"	"
1046	017		" " "	"	2330 hrs
1047	017		" " "	"	"
1048	017	MJC 209	" " "	"	"
1049	018	MJC 211	" " "	"	2400 hrs
1050	018		" " "	"	"
1051	019	MJC 208	Raw Product Water	"	2330 hrs
1052	019	JB 667	" " "	"	"
1053	020	MJC 210	Treated Product Water	"	2345 hrs
1054	020	JB 668	" " "	"	"
1055	020	JB 668	" " "	"	"
1056	021	JB 669	Product Solids	"	2400 hrs
1057	021	MJC 212	" "	"	"
1058	022	MJC 213	" " (dup)	"	"
1059	---		Top of Solids Bin	"	"
1060	023		Raw Product Water	2/27	0015 hrs
1061	023		" " "	"	"
1062	024		Raw Sludge	"	0030 hrs
1063	024		" "	"	"
1064	026		Product Oil	"	0100 hrs
1065	026		" "	"	"
1066	026		" "	"	"
1067	026		" "	"	"
1068	027	JB 670	Treated Product Water	"	0345 hrs
1069	027	JB 671	" " "(Dup)	"	"
1070	027		" " "	"	"
1071	027	MJC214,MJC215	" " "	"	"
1072	028	MJC 216	" " "	"	0445 hrs
1073	029	MJC 217	" " "	"	0500 hrs
1074	029	JB 673	" " "	"	"
1075	029	JB 674	" " "	"	"
1076	030		Raw Sludge	"	0545 hrs
1077	---		Oil Polisher Outlet	"	0630 hrs

TABLE 54 (CONT'D)

SAMPLE KEY FOR B.E.S.T.^{TM} SLUDGE PROCESSING BDAT TEST

Sample Tag #	RMAL #	EPA #	Sample Description	Date	Time
1078	032		Product Oil	2/27	0315 hrs
1079	032		" "	"	"
1080	032		" "	"	"
1081	033	JB 672	Treated Product Water	"	0445 hrs
1082	033	JB 672	" " "	"	"
1083	034		" " "	"	0500
1084	037		" " "	"	"
1085	035		Product Oil	"	0515 hrs
1086	035		" "	"	"
1087	035		" "	"	"
1088	036		" "	"	0630 hrs
1089	036		" "	"	"
1090	038		" "	"	"
1091	038		" "	"	"
1092	036		" "	"	"
1093	036		" "	"	"
1094	038		" "	"	"
1095	038		" "	"	"
1096	039		Raw Sludge	"	0730 hrs
1097	---		Top of Solids Bin	"	0815 hrs
1098	040	MJC 218	Product Solids	"	"
1099	070	MJC 219	" "	"	"
1100	---				
1101	---				
1102	---				
1103	---				
1104	---				
1105	041	MJC 220	Product Solids	2/27	0845 hrs
1106	042		Raw Product Water	"	0915 hrs
1107	042		" " "	"	"
1108	042	MJC 221	" " "	"	"
1109	042	MJC 222	" " "	"	"
1110	043		Raw Sludge	"	0925 hrs
1111	045		Product Oil	"	0915 hrs
1112	073		" "	"	"
1113	---				
1114	---				
1115	046		Product Solids	2/27	0815 hrs
1116	047	JB 675	Raw Product Water	"	0920 hrs
1117	047	JB 675	" " "	"	"
1118	---				
1119	048		Product Oil	2/27	1400 hrs

TABLE 54 (CONT'D)

SAMPLE KEY FOR B.E.S.T.^{TM} SLUDGE PROCESSING BDAT TEST

Sample Tag #	RMAL #	EPA #	Sample Description	Date	Time
1120	048		Product Oil	2/27	1400 hrs
1121	049		" "	"	"
1122	049		" "	"	"
1123	049		" "	"	"
1124	049		" "	"	"
1125	049		" "	"	"
1126	049		" "	"	"
1127	050		Raw Sludge	2/27	1100 hrs
1128	051		" " (dup)	"	"
1129	---				
1130	---				
1131	052	MJC224/JB677	Product Solids	2/27	1015 hrs
1132	053		Raw Sludge	"	0945 hrs
1133	054		Treated Product Water	"	0930 hrs
1134	---				
1135	---				
1136	054	MJC 223	Treated Product Water	2/27	0930 hrs
1137	031	JB 685	Field Blank		
1138	---	JB 677	Product Solids	2/27	1015 hrs
1139	---	JB 677	" "	"	"
1140	044				
1141	056	MJC 225	Raw Product Water	2/27	1045 hrs
1142	056	JB 678	" " "	"	"
1143	056	JB 679	" " "	"	"
1144	057		Water Trtmt. Blowdown	"	1120 hrs
1145	058		Product Oil	"	1130 hrs
1146	058		" "	"	"
1147	059	JB 680	Product Solids	"	1135 hrs
1148	059	MJC 226	" "	"	"
1149	060	JB 681	" "	"	1200 hrs
1150	060		" "	"	"
1151	062		" "	"	"
1152	062	MJC 368	" "	"	"
1153	063	JB 682	Treated Product Water	"	1205 hrs
1154	063	MJC 367	" " "	"	"
1155	---	JB 684	Field Blank		
1156	064		Raw Sludge	2/27	1245 hrs
1157	---				
1158	065		Raw Sludge	2/27	1300 hrs
1159	065		" "	"	"
1160	066		Water Trtmt Blowdown	"	1330 hrs
1161	067		Product Oil	"	"
1162	055	JB 687	Field Blank		
1163	025				

TABLE 54 (CONT'D)

SAMPLE KEY FOR B.E.S.T.^{TM} SLUDGE PROCESSING BDAT TEST

Sample Tag #	RMAL #	EPA #	Sample Description	Date	Time
1164	061	JB 688	Field Blank		
1165	068		Product Oil	2/27	0100 hrs
1166	074		" "	"	"
1167	074		" "	"	"
1168	068		" "	"	"
1169	069	JB 686	Field Blank		
1170	---				
1171	---		Oil Polisher Outlet	2/27	1130 hrs
1172	---		Top of Solids Bin	"	1135 hrs
1497	---		Oil Polisher Outlet	2/26	1845 hrs
1499	---		Raw B.E.S.T. Prod. H2O	"	1800 hrs
RCC 7040-68	---		Raw Sludge	"	1345 hrs
RCC 7040-71	---		Raw Sludge	2/27	0017 hrs

APPENDIX C
MATERIAL SAFETY DATA SHEET

MATERIAL SAFETY DATA SHEET

EFFECTIVE DATE: MARCH 1, 1986

Union Carbide Corporation urges the customer receiving this Material Safety Data Sheet to study it carefully to become aware of hazards, if any, of the product involved. In the interest of safety you should (1) notify your employees, agents, and contractors of the information on this sheet, (2) furnish a copy to each of your customers for the product, and (3) request your customers to inform their employees and customers as well.

I. IDENTIFICATION

PRODUCT NAME:	TRIETHYLAMINE		
CHEMICAL NAME:	Triethylamine	CHEMICAL FAMILY:	Alkylamines; Nitrogen Compounds
FORMULA:	$(C_2H_5)_3N$	MOLECULAR WEIGHT:	101.19
SYNONYMS:	TETN		
DEPARTMENT OF TRANSPORTATION	Hazard Classification Shipping Name	Flammable Liquid Triethylamine	
CAS # 121-44-8	CAS NAME	1-Ethanamine, N, N-Diethyl	

II. PHYSICAL DATA

BOILING POINT, 760 mm Hg	89.5°C (193.1°F)	FREEZING POINT	-114.7°C (-174.5°F)
SPECIFIC GRAVITY (H_2O = 1)	0.7290 at 20/20°C	VAPOR PRESSURE at 20°C	54 mm Hg
VAPOR DENSITY (air = 1)	3.5	SOLUBILITY IN WATER, % by wt.	5.5 at 20°C
PERCENT VOLATILES BY VOLUME	100	EVAPORATION RATE (Butyl Acetate = 1)	5.60
APPEARANCE AND ODOR	Water-white liquid; fish-like odor		

III. INGREDIENTS

MATERIAL	%	TLV	HAZARD
See Page 4			

IV. FIRE AND EXPLOSION HAZARD DATA

FLASH POINT	17°F, Tag closed cup, ASTM D 56; 20°F, Tag open cup ASTM D 1310			
FLAMMABLE LIMITS IN AIR, % by volume	LOWER	1.2	UPPER	8.0
EXTINGUISHING MEDIA	Apply alcohol-type or all-purpose-type foams by manufacturers' recommended techniques for large fires; carbon dioxide or dry chemical media for small fires.			
SPECIAL FIRE FIGHTING PROCEDURES	Use water spray to cool fire-exposed containers and structures. Fight fire with remote spray monitors or from behind shields. Use self-contained breathing apparatus and protective clothing.			
UNUSUAL FIRE AND EXPLOSION HAZARDS	Vapors form from this product and may travel or be moved by air currents and ignited by pilot lights, other flames, smoking, sparks, heaters, electrical equip., static discharges, or other ignition sources at locations distant from handling point. Combustion products are severely irritating to the skin, eyes, nose, and respiratory system.			

EMERGENCY PHONE NUMBER • 1-800-UCC-HELP • This number is available days, nights, weekends, and holidays.

V. HEALTH HAZARD DATA

TLV AND SOURCE:

10 ppm: ACGIH 1985-86 and OSHA CFR 29, para 1910.1000, Table Z-1.

EFFECTS OF ACUTE OVEREXPOSURE

SWALLOWING	May cause chemical burns of the mouth, throat, and esophagus. Signs and symptoms will include pain or discomfort in the mouth, throat, chest, and abdomen, nausea, vomiting, diarrhea, dizziness, drowsiness, faintness, weakness, collapse, and coma.
SKIN ABSORPTION	Prolonged or widespread skin contact may result in the absorption of potentially harmful amounts of material.
INHALATION	Exposure above the TLV may cause irritation to the respiratory tract, with sneezing, coughing, burning sensation of throat, constricting sensation of the larynx, and difficulty in breathing. High concentrations may cause damage liver, kidney, and heart damage, tracheitis, bronchitis, pneumonitis, and pulmonary edema.
SKIN CONTACT	Vapor may cause skin irritation experienced as itching and local redness. Exposure to liquid may cause severe local redness with swelling, and chemical burns with necrosis of the skin.
EYE CONTACT	Vapor may cause irritation and temporary disturbance of vision (see Notes to Physician). Liquid may produce severe irritation experienced as excess redness and swelling of the conjunctiva with chemical burns of the cornea.

EFFECTS OF REPEATED OVEREXPOSURE

May cause low grade dermatitis and conjunctivitis.

OTHER HEALTH HAZARDS

May cause skin sensitization and development of allergic contact dermatitis in a small proportion of individuals and may aggravate an existing dermatitis. Inhalation may aggravate asthma and inflammatory or fibrotic pulmonary disease.

EMERGENCY AND FIRST AID PROCEDURES:

SWALLOWING	Rinse mouth with water. Give at least 2 glasses of water or milk at once, if the patient is conscious. Do not induce vomiting. Call a physician.
SKIN	Immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Discard clothing and shoes. Call a physician.
INHALATION	Remove to fresh air. Give artificial respiration if not breathing. Oxygen may be given if necessary. Call a physician.
EYES	Immediately flush eyes with water for at least 15 minutes. The eyelids must be held open and away from the eyeball to ensure that all surfaces are flushed thoroughly. Seek immediate medical attention, preferably an ophthalmologist.

VI. REACTIVITY DATA

STABILITY

UNSTABLE	STABLE
	X

CONDITIONS TO AVOID Avoid fires, sparks and heat.

INCOMPATIBILITY (materials to avoid) Strong mineral acids (sulfuric, hydrochloric, nitric); oxidizers (liquid oxygen, ozone, peroxide); chlorine; hypochlorites; ketones; aldehydes (acrolein); epoxides; esters; alkylhalides (carbon tetrachloride, trichloroethylene, etc.)

HAZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS Burning can produce nitrogen oxides, carbon monoxide, and carbon dioxide.

HAZARDOUS POLYMERIZATION

May Occur	Will Not Occur
	X

CONDITIONS TO AVOID Will not polymerize, but may catalyze polymerization of epoxides or aldehydes (especially acrolein).

VII. SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED Extinguish and do not turn on any ignition source until area is determined to be free of fire or explosion hazard. Wear suitable protective equipment; avoid contact with liquid and vapors. Collect for disposal. Highly toxic to fish! Avoid discharge to natural water

WASTE DISPOSAL METHOD Incinerate in a furnace where permitted under appropriate Federal, State, and local regulations.

VIII. SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION Self-contained breathing apparatus in high concentrations.

VENTILATION This product should be handled within covered, vapor-tight equipment, in which case general (mechanical) room ventilation is satisfactory. Special, local ventilation is needed at points where vapors can escape to the air.

PROTECTIVE GLOVES Plastic

EYE PROTECTION Monogoggles

OTHER PROTECTIVE EQUIPMENT Eye bath and safety shower

IX. SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING
Do not get in eyes, on skin, on clothing. Keep away from heat, sparks, and flame. Avoid breathing vapor. Keep container closed. Use with adequate ventilation. Wash thoroughly after handling.

FOR INDUSTRY USE ONLY

OTHER PRECAUTIONS
See Page 4

The opinions expressed herein are those of qualified experts within Union Carbide Corporation. We believe that the information contained herein is current as of the date of this Material Safety Data Sheet. Since the use of this information and these opinions and the conditions of use of the product are not within the control of Union Carbide Corporation, it is the user's obligation to determine the conditions of safe use of the product.